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ORIGINAL ARTICLES.

I.—On Mesozoic Angiosperms.

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(PLATE V.)

THERE can scarcely at the present time be a problem more interesting than that of the first appearance of Angiosperms, nor one regarding which there is less trustworthy information at the disposal of the geologist. In attempting to bring together a summary of what is known regarding the earlier forms of this most important division of the vegetable kingdom, I make little claim to originality; nor are such criticisms as I may venture upon entitled to the same weight as if put forward by a trained botanist.

It is quite unnecessary to recall the many supposed representatives of Angiosperms that were formerly included in the Palæozoic Floras, for they have long since been dismissed from our lists of fossils and forgotten. Though less fanciful in degree than some of the still earlier geological fallacies, they are no less mythical, and at present the names *Yuccites*, *Palmacites*, *Antholites*, *Poacites*, *Culmites*, etc., are no longer included among the plants of the Coal-measures. Now that *Pothocites* has been shown to be part of a Sigillarian plant, there is in fact no longer any Angiosperm remaining of Palæozoic age. At the same time, it must not be overlooked that Corda described two species of Carboniferous and Permian endogenous wood, while the exhaustive studies of Prof. Williamson, extending over a great number of years, have brought to light the existence of some anomalous woods and other plant-structures from the Coal-measures, in the most perfect preservation, so that it is certainly within the bounds of possibility that we may some day come to a clearer appreciation as to the lines through which Angiosperms were differentiated from the older Cryptogams or Gymnosperms.

There are met with, however, in the Coal-measures, the exceedingly problematical remains of a plant which is claimed in the latest work of Saporta and Marion to be a "pro-Angiosperm," or, in other words, an Angiosperm imperfectly differentiated from a Cryptogamic or Gymnospermic stock. The widely-distributed fossil, known as *Spirangium*, consists of acutely-pointed spindle-shaped bodies, which are believed to be composed of from five to ten linear valves, supposed to envelope a central cavity. These valves usually appear to be spirally twisted, but in some specimens, which seem to

be in more perfect preservation, there is no twist visible,[1] so that it is probable that either the spiral arrangement was confined to an inner part of the structure, or that the purpose they had to serve could be equally fulfilled without the twist. They seem to have been seated on a pedicel, and according to Schimper, a number were joined to form a sort of umbel; but in England at least they are generally found detached. Examples were figured in the Transactions of the Geological Society as long since as 1840,[2] under the name of *Carpolithes helicteroides*. No better idea of their enigmatical nature can be given than the bare enumeration of some of the guesses that have been made as to their affinities. They were thought to be allied to *Helicteres*, a genus of *Sterculiaceæ*, by Prestwich and Morris: they are *Palæobromelia* of Ettingshausen, allied to the Pine-apple family; the *Palæoxyris*, of Brongniart, related to *Xyris*,[3] a sedge-like Monocotyledon principally confined to the Tropics; the radicular appendages of *Equisetum* according to Lesquereux; they were named *Sporlederia* by Stickler, who regarded them as Bromeliads; and *Spirangium* by Schimper, who hazards no opinion as to their position in the vegetable kingdom, beyond such as is implied by placing them after the Monocotyledons. Finally, they are claimed to be "pro-Angiospermous" fruits by Saporta and Marion, but it is almost superfluous to say that their affinities remain to this day completely unknown. They are found in all stages, from the Carboniferous up to and including the Wealden, and any discovery tending to shed further light upon them would be of very great importance.[4]

Next in point of age comes a leaf with reticulated venation from the Permian of Russia, and named *Dichoneuron Hookeri*, Sap. It is stated to be of a firm consistence, with a long petiole, slightly dilated at the base and detached naturally from the stem; and an engraving shows it to be bipartite, indented, and lobed and cut laterally into two segments. Saporta and Marion[5] claim that the venation resembles that of *Pistia* (a tropical Duckweed), and that the leaves of the aroideous *Amormophyllum* are similarly bilobed, and suggest the association with it of a spathe-like body from the same formation. Sir Joseph Hooker, however, to whom the specimen was shown, thought that it was probably a cryptogam allied to *Ceratopteris*, a genus of tropical and aquatic Ferns. It is in any case quite obvious that very little importance can be attached to a mere leaf with such undecided characters, when we reflect that leaves greatly resembling each other with not dissimilar venation are common alike to Cryptogams, Gymnosperms, and both divisions of Angiosperms. Another

[1] There is an admirable specimen showing this condition in the Museum at Owens College.

[2] Prestwich, Geology of Coalbrook Dale, Geol. Trans. vol. v. part iii. plate 38, fig. 12, and explanation by Prof. Morris.

[3] A view recently upheld by Nathorst.

[4] The species described as *Palæospathe* by Unger from the Carboniferous and Permian, may possibly also belong here. A list of them is given in Schimper, Pal. végétale, vol. ii. p. 505.

[5] Evolution des Phanérogams, vol. i. p. 231.

problematic plant, of which the outline at least is perfectly known, is the *Œthophyllum speciosum*, Sch. and Moug., from the Trias of the Vosges. It possessed linear leaves, with fine linear veins without mid-rib, which are decurrent and grouped by threes on a woody and branching stem. The branches are terminated by cylindrical and more or less elongated spikes, whose scales or bracts bore smooth shining seeds in their axils. These spikes were imperfectly articulated at the base and furnished at that point by a ring of paleæ or hairs, and were probably caducous.[1] It has been suggested by several writers that *Œthophyllum* may be allied to the *Typhaceæ*, and though it is by no means even certain that they belong to the Monocotyledons at all, it appears difficult to avoid regarding them with interest as at least possible "pro-angiospermic" types. Certain fruit-spikes from the same formation were named *Echinostachys* by Brongniart.

Synchronous with the last, and also common to the Jurassics, are narrow ribbon-like leaves known as *Yuccites*, Sch. and Moug., five species of which are described by Zigno.[2] They are broad or narrow linear leaves, with entire margin, and without mid-rib, with fine longitudinal veins united by transverse veinlets and sessile or amplexicaul base. As stated by Schimper,[3] "It is useless to remark that these fossils may proceed from very different types, and perhaps without real analogy with the living type to which we compare them." They most resemble the leaves of *Dracæna* or *Fourcroya*.

In the Rhætic we meet for the first time with the remarkable organism known as *Williamsonia*, a fossil familiar to us from its not uncommon occurrence in the Oolite of Yorkshire. It appears to have been figured first as a flower[4] in Bird's Yorkshire, pl. ii. fig. 6, associated with *Zamites*, and later by Mantell in 1844, Medals of Creation, vol. i. p. 161, as the fruit of *Zamites lanceolata*, in consequence of a conjecture by Lindley that the supposed petals were scales and the stamen and pistil the fractured axis. It was first described by Prof. Williamson in a communication to the Linnean Society,[5] in 1868, and was named after the Professor by Carruthers; but at that time it was considered that the Cycadean foliage associated with it, and known as *Zamites gigas*, might very probably belong to the same plant. The fructification is very rarely attached to stems with spirally arranged leaves, and to such stems and the fruit the genus is now restricted. It seems no longer possible to regard it as even an utterly abnormal Cycad, and the question therefore arises as to whether Saporta and Marion have sufficient grounds for ranking it among their "pro-Angiosperms." Mr. Carruthers and Prof. Williamson appear uncertain as to which section of the vegetable kingdom it should enrich, while Dr. Nathorst advances the rather untenable proposal to place it in *Balanophoraceæ*, a small natural order of succulent leaf-less,

[1] Schimper and Mougeot, Monogr. d. pl. foss. du Grès bigarré, p. 39, pl. xix. xx.
[2] Flora foss. forma. oolithicæ, i.-iv.
[3] Pal. végétale, vol. ii. p. 427.
[4] A closed bud is apparently figured as a nut, pl. iii. fig. 7.
[5] Linn. Trans. p. 663, pls. 52 and 53.

parasitic Dicotyledons, to which *Rafflesia* belongs, while Newberry appears to regard them as possible Composites.[1]

The branches of *Williamsonia gigas*, Carr., are stout, densely clothed, with remarkably thick and short sheathing leaves, amplexicaul, loosely imbricated, dorsally keeled or convex, inferiorly canaliculate, and with lanceolate, stiff, and even spinous apex. They are coriaceous, smooth, with entire margins and parallel veins, united by a delicate network of oblique veinlets only visible with a lens. Many of these stems are terminated by more or less developed globose involucres, composed of at least one whorl of converging linear bracts, bent inwards so as to form a chamber, which is sometimes empty, showing the basal scar from which the interior organ had become detached. The largest of these involucres are formed of several rows of bracts enveloping a peculiar gourd-shaped body or axis invested with a dense covering of compressed long narrow cells, which Saporta regards as an investing mass of filaments and anthers, such as that covering the spadix of *Typha*. Prof. Williamson calls this a cortical layer, but has inferred that it possibly bore antheridial organs: Saporta adds that these fell away after the pollen was shed, leaving the axis bare. Saporta asserts, and Williamson thinks it not improbable, that this involucre represents the male organ of the plant.

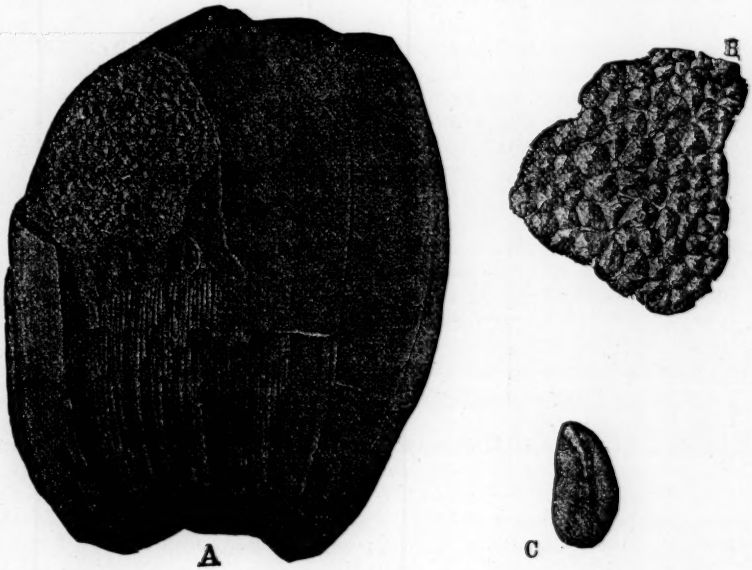
Associated with them are found verticils of incurved bracts united at their bases into a cup-shaped organism, which Williamson on the one hand is confident have never been found attached to any other, but which Saporta maintains are sometimes present in the interior moulds, in which condition all the English specimens are found, adhering to the gourd-shaped axis which he says it surmounted. The important collection of Mr. Yates is now in the Jardin des Plantes, and I have not had the opportunity of examining it since I became interested in the subject; but on the other hand Professor Williamson certainly possesses a specimen in which each bract is furnished with a pair of oblong depressions, which are clearly not accidental markings as Saporta would believe, and are obviously adapted for bearing a pair of ovules. The remarkable thing is that none of the other numerous specimens, so far as I know, in our public museums show any such marks. Moreover, the gourd-shaped axis is sometimes prolonged into a peculiar point which can be most readily described as in shape like a light-house, and which finds no place in Saporta's restoration.[2]

The rest of the description of *Williamsonia* is taken wholly from

[1] Dr. Newberry describes a number of helianthoid flowers which he calls *Palæanthus*, from the Cretaceous Amboy Clays, which are three to four inches in diameter and greatly resemble *Williamsonia*. He remarks that though "so much like flowers of Compositæ, we are not yet warranted in asserting that such is their character," Bull. Torrey Botanical Club, vol. xiii. p. 37, 1886.

[2] The cup is described by Saporta and Marion, Evolution des Phanérog. vol. i. p. 240, as a large cup or bell-shaped expansion with fringed or lobed margin, composed of coriaceous and fibrous tissue, comparable to the spongy apex of the fleshy spadix of *Amorphophallus*, and more remotely with the tuft of leaves crowning the Pine-apple.

Saporta and Marion,[1] as the specimens preserved in museums in this country do not appear to reveal the characters claimed by these distinguished French authors. They say that in addition to the male involucres are others, smaller, less regularly globose, generally empty, with a broad cicatrix at the base, corresponding to the insertion of an organ which has evidently become detached in a natural manner. Complete specimens, however, show a globular receptacle or spadix, shrunk as if empty and surrounded by the bracts forming the involucre. Sometimes this involucre appears to have been detached entire, but more often the globular spadix with the inner row only of bracts was disarticulated. The surface of the spadix itself is areolate, the compartments irregularly polygonal, either grouped in rosettes of five or six round central points, which appear to be stigma of ripe pistils, or with these latter more irregularly interspersed among them. The areolæ are presumably barren carpels. An Indian specimen shows the female spadix to have possessed a fibrous covering which was shed in a single piece. A



A. Fruiting organ of *Williamsonia Morieri*, Sap., naturally shed. The specimen is preserved as carbonate of iron. Some of the bracts of the involucre remain, and beneath the areolæ an accident has exposed some of the ripe seeds in their natural position. The specimen, magnified twice, is from the Oxfordian of Vaches-Noires. *B*. Areolæ formed of carpels grouped together and compressed, the central points being the scars of the stigmas. *C*. A seed greatly magnified. After Saporta and Marion.

[1] Saporta has an exhaustive treatise on the subject in the press, which will be superbly illustrated, in which he intends to demonstrate the absolute identity of *Williamsonia* with *Podocarya*.

very perfect specimen of *Williamsonia Morieri*, beautifully preserved in carbonate of lime, is from the Oxfordian of Calvados. In this species only the upper half of the spadix, which is ovate instead of globose, is covered with areolæ, in consequence of the fibres of which the areolate covering is formed being directed upwards obliquely, instead of at right angles to the axis. This disposition has fortunately enabled some of the ovules to be uncovered, and shows that they are situated in the interior of the rosettes in which the areolæ are arranged, each one corresponding to an entire rosette. Thus most of the pistils were unfertilized, supposing there were as many pistils as areolæ, and several of them became subsequently united into syncarps. Each areola when magnified is polygonal and convex, with the facets culminating in a small button, an arrangement exactly similar to that of *Pandanus fragrans*. The ovules or seeds were attached by the base, which was rounded, while the other end was more pointed.

The spadix was not a true inflorescence, or spike composed of a number of flowers on one axis, as in the true *Spadiciflorœ*, but a branch with every leaf metamorphosed into carpels, and thus the morphological equivalent of the gynœcium of the *Magnolia*. Consequently it represents a single flower composed of an indefinite number of unisexual elements, a structure of a kind that might *a priori* have been expected to occur in an early type of pro-Angiosperm.

Small buds, as well as the more mature organisms, are met with in the Yorkshire Oolites. Other and distinct species have been met with in the Oolites of India,[1] France, and some of the Baltic provinces, in some of these cases apart from any associated Cycadean remains.[2] An organism found by Griffiths in the Grey Chalk between Dover and Folkestone, in which the coaly substance of the plant is preserved, was forwarded by me to Saporta, who pronounced it without hesitation to be a *Williamsonia*. It would be interesting to have this determination confirmed, as it strengthens the evidence already in existence, tending to show that no great change took place in the Flora of the British area, from the Jurassic to the Cretaceous, inclusive.[3]

The oldest definite Monocotyledons however are the well-marked Pandanaceous fruits from the Oolites, which therefore take rank as the earliest known Angiosperms. One of the most distinct of these was figured by Buckland in 1836 from the Inferior Oolite of Charmouth,[4] to which, at R. Brown's suggestion, he gave the name

[1] Feistmantel lays great stress on their occurrence in the rocks of the Rajmahal group as supporting his view that they are of Jurassic age. There are two species besides the one considered identical with the Yorkshire *W. gigas*, Pal. Indica, Flora of Kach, p. 73, 1876.

[2] Williamson, On some Anomalous Oolitic and Palæozoic Forms of Vegetation, Proc. Roy. Institution of Great Britain, Feb. 16, 1883.

[3] Saporta writes to me under date April 2nd, 1886, regarding this fossil:—"Je crois bien que c'est un véritable *Williamsonia*, mais écrasé et méconnaissable et je n'ose pas le décrire dans l'état où il est, ne sachant même si ce ne serait pas quelque type spécial." It appears, however, that it is to be figured in a forthcoming work.

[4] Geol. and Min. vol. i. p. 504; vol. ii. p. 101. Unger, Gen. et Spec. Plant. Foss. p. 327.

Podocarya. Carruthers redescribed it[1] as of "the size of a large orange, and composed of an indefinite number of cells, each containing, near the surface, a single longish seed, about the size of a grain of rice. The cells were separated from the spadix by long fibrous footstalks, and were surmounted by hexagonal tubercles, in the centre of which could be seen the remains of a stigma." The resemblance of this fruit to that of *Williamsonia* when deprived of its involucre should not be overlooked.[2] Another Pandanaceous fruit from the Great Oolite of Kingsthorpe, near Northampton, is named *Kaidacarpum* by Carruthers and is thus described (p. 155, *op. cit.*):[3]—

"The fruit consists of a thick spadix,—not so thick, however, in proportion to the drupes as in *Bryantia butyrophora*, Webb. The drupes leave the spadix at a right angle about one-third from the apex, those above have an ascending and those below a descending direction, increasing as it reaches the fruit-stalk, which is seen in the fossil, and shown in the drawing. This arrangement is precisely that of *Sussea conoidea*, Gaud. The drupes are rhomboidal at the base, spreading out laterally towards the apex, where their form is a broad compressed rhomb two or three times longer than it is broad. The cell containing the seed is near the base of the fruit, leaving only a short pedicle or being really sessile, as in the recent species with single-seeded drupes. Each drupe contains a single seed; and although the whole structure is replaced by calcite, yet the details are so beautifully shown that the connection of the seed by an internal unilateral placenta adnate to the whole length of the cell is in many cases obvious. The seed is ovoid and compressed and the cicatrix at its base, by which it was attached to the placenta, can be detected." A comparison of the fossil with *Sussea conoidea*, Gaud., places it beyond doubt, in the author's opinion, "that it is a true *Pandanaceous* fruit." Another less perfectly preserved species is in the Woodwardian Museum from the Potton Sands of Cambridgeshire, and figured by Lindley and Hutton, but it is certainly a derived fossil, and of Jurassic age. Another is recorded from the Upper Greensand of Wiltshire. It was originally figured

[1] Geol. Mag. Vol. V. April, 1868, Pl. IX. pp. 153-156.

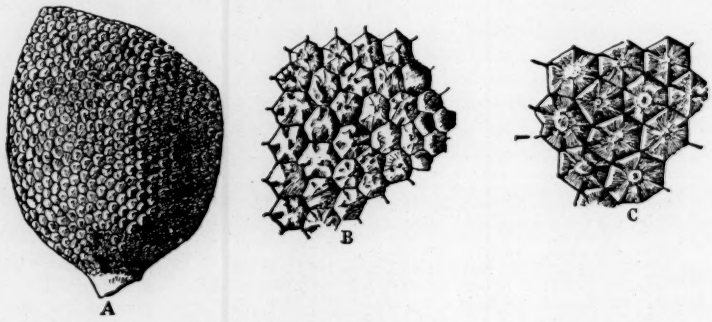
[2] See note *ante*. I was not in the least aware of Saporta's conclusion when this was written.

[3] The mode of preservation is important, and is stated to be as follows:—"The matrix in which it is preserved is an amorphous cream-coloured limestone, which has abounded in Molluscan remains, but the shells have been removed, and the spaces they occupied, as well as the other larger cavities in the rock, are lined with or entirely filled up by crystallized calcite. The fruit also is only a cast in the same material, of the cavity which originally contained it. The fine white mud had insinuated itself into every crack and opening of the fruit, and filled the decayed interior of the upper portion of the drupes. The walls of the seed cavity and the seeds themselves, as well as the outer membrane of the drupes, resisted decay until the matrix was somewhat compacted. These hard portions at length decayed, but the insoluble carbon remained as a black amorphous substance, giving an external coloured coating to the crystallized carbonate of lime, which in the end filled the cavity, preserving in the most perfect manner the form of the fruit, and even some of the minute details as to the relation of the different parts." Geol. Mag. *l.c.*

by Lindley and Hutton as *Strobilites Bucklandi*, in their Fossil Flora, vol. ii. pl. 129, published in 1833–35, from a drawing by Miss E. Benett, made for Dr. Buckland, without the least clue as to age or locality in the descriptive letterpress. In Miss Benett's "Catalogue of the Organic Remains of Wiltshire," published in 1831, the only fossil referred to, which could possibly be the *Strobilites* in question, is a *Cycadeoidea?* from the Portland Beds, under the heading "Woods," p. 9. In the first edition of Morris's Catalogue, 1843, it is put down as from "Gr. S. Wilts," which cannot mean either Lower or Upper Greensand, the abbreviations for which are "L. G. S.," and "U. G. S." but which looks like a misprint for "Gr. O.," the sign for Great Oolite. In the second edition Morris, 1854, it appears as from "U. G. S. Wiltshire." The question is whether in correcting the printer's error of the first edition, due care to ascertain the facts *de novo* was used. The circumstances are such as to leave the age of the fossil in considerable doubt.

Part of a similar fruit is also described by Heer from the Cretaceous of Patoot in Greenland.

A not dissimilar but still smaller fruit has been found in the Coralline Oolite and the Kimmeridge Clay in France. These, named *Goniolina*, are small ovoid, aggregated fruits, like those of *Pandanus*, borne on a naked, cylindrical and relatively slender petiole. The heads of the very numerous fruits are arranged in spirals and regular, closely pressed together and barely a millimètre across. They are of hexagonal shape, and six keels extend from the angles and meet in a raised point in the centre. The interior axis is cylindrical, and impressed with scars made by the bases of the fruits, completing its likeness to *Pandanus*.



Goniolina. Fruiting organ. From the Jurassic, in the Paris Museum. After Saporta and Marion.

The *Aroïdes Stutterdi*, from the Great Oolite,[1] must, it appears on the other hand, be expunged from the list of fossil plants, for Dr. Woodward has well-nigh conclusive evidence proving that this calcareous organism is part of an Echinoderm, *Apiocrinus* (*Millericrinus*) *Prattii*. *Poteriocrinus* and *Platycrinus* are furnished with

[1] See paper by W. Carruthers, F.R.S., Geol. Mag. 1867, Vol. IV.

singular prolongations emerging from the calyx, known as the "proboscis" (really the efferent orifice), which exactly resemble externally the spadices of large Aroideous flowers.[1] Though the calyx and "proboscis" have not been found united in this particular species, the fact that the supposed spadix is calcareous, and is far from uncommon in a purely marine formation, renders it in the highest degree improbable that it could be any portion of the flower of an Aroid such as *Xanthosoma*. These singular crinoid probosces were however not known when the determination was made. It is a remarkable fact, that up to the present, there are no fossil representatives of the *Aroideæ* described, save a single fragment from the Tertiary of Eriz, in Switzerland, named *Aronites dubius* by Heer, a determination thought by Schimper to be doubtful. Our Eocene Flora, however, contains several important representatives of the group.

Several quite distinct types of Monocotyledons have been recorded from the Lias, the principal of these being *Bambusium liasinum*, Heer,[2] a leaf very similar to those mentioned as *Yuccites* without mid-rib and with two to four fine veins alternating with every more decided one. Stems supposed to have been solid and cylindrical and jointed are said to have been found associated with the leaves. Some other fragments described as *Cyperites protogæus*, Heer, supposed to be a species of *Cyperaceæ*, and *Zosterites tenuistriatus*, Heer, possess no characters whatever on which any opinion should have been expressed, and must certainly be expunged. The stems of *Endogenites erosa*, so common in the Wealden and Neocomian, are now known to be Cycadeous, and it is probable that the *Dracæna*-like stems from Tilgate Forest and elsewhere, so often referred to by Mantell, are referable to the same group. There are also many Jurassic-Cretaceous fruits which may quite conceivably prove to be angiospermous, and which deserve careful study.

The remarkably fine stem I have figured is in the possession of Prof. Williamson, who states that it is the *Calamites Beanii* of Bunbury.[3] Sir Charles, however, remarks on the tumid articulations, "the stem being much thicker in those parts than in the intermediate spaces," so that he must have had specimens of *Equisetum columnare*, which occur abundantly in the same beds, in his mind. In speaking of it Prof. Williamson observes that "so far as external appearances are concerned, it more closely resembles the stem of one of the arborescent *Gramineæ*. But such appearances have very little Taxonomic value. Nevertheless, the plant stands out in prominent distinctness from amongst the Ferns, Cycads, and Conifers that grew around it, forcibly suggesting the idea of an arborescent Monocotyledon ; and if such has been its character, its position amongst these older Oolites would make

[1] Although this conclusion seems highly probable, it must be borne in mind that *at present* we know of *no Secondary* stalked crinoid with a "proboscis" like *Poteriocrinus* or *Platycrinus*. All the forms with this appendage being of Palæozoic age.—H. W.

[2] Heer, Flora Helvetiæ, p. 138, pl. 55.

[3] Quart. Journ. Geol. Soc. vol. vii. p. 189, *C. giganteus*, Bean MS.

it, if not the earliest, one of the earliest representatives of the Monocolytedonous group."[1] The stem is somewhat compressed, and the piece preserved is evidently from near the base, the three joints of which it is composed diminishing rapidly, the first measuring 2 inches, the second $1\frac{3}{4}$, the third $1\frac{1}{2}$ inches in height. The diameter of the middle joint is about 5 inches, but its crushed condition has no doubt considerably added to the width, which was probably nearer $3\frac{1}{2}$ inches before compression. The exterior has a smooth and silky look, with fine longitudinal veins. The nodes are depressed, about $\frac{1}{16}$ of an inch wide, and bordered by slight collars or thickenings. The stem seems to have been hollow, though it may perhaps have been solid like the sugar-cane; it has an altogether different texture to that of *Calamites* or *Equisetum*. There are unfortunately no other organs in these beds which can be even tentatively united with it.

Supposed Monocotyledonous stem from the Jurassic of Yorkshire.

[Owing to the unfortunate loss of the wood engraving in transit by rail, the figure of Prof. Williamson's specimen had at the last moment to be omitted, but will be inserted in the June Number.—Edit. Geol. Mag.]

The specimen figured, Plate V. Fig. 1, *a* and *b*, is now in the Woodwardian Museum, and is also stated to have come from the Yorkshire Oolites. As in all fossil vegetables from these deposits, there is no internal structure preserved, and we are therefore only able to deal with the exterior. This appears to represent on one side a ropy ligneous stem, slightly twisted, and with a half-lunar section. On the other side is a thick, closely adherent spathe, rather smoother than the stem, but furrowed, very thick and leathery, acutely pointed at the top, and narrowed and amplexicaul at the base. The spathe or pod is 9 inches long, $2\frac{1}{2}$ broad, and $1\frac{1}{2}$ inches deep in its greatest diameter. There is a slight swelling near the base, with two or three projections, as if there were ovules under the spathe, then a contraction, and then the main swelling with apparent traces of more ovules under it, especially towards the apex. The seeds or fruits would appear to be oval and about half an inch in length. At the base, where the spathe joins the stem, its substance is seen to be $\frac{1}{16}$th of an inch in thickness, and it is an inch across; the stem itself being $1\frac{1}{4}$ inches wide, rather compressed and squarish. It increases upward with the spathe, becoming more crescentic in section, and again diminishes as the spathe commences to taper to a point. Though the transverse section reveals no structure, it shows clearly the demarcation between spathe and fruit and the stem.

It forcibly reminds us of some palm spathes and fruits, and if it should prove to be merely concretionary, it would certainly be a case of most extraordinary mimicry. Such a view seems however, quite out of the question, and we cannot help regarding it as a mono-

[1] On some Anomalous Oolitic and Palæozoic Forms of Vegetation, Royal Instituion, Feb. 16, 1883.

cotyledonous fruit of some kind, and greatly regret that its precise locality and horizon cannot be fixed with greater precision.

The supposed *Najadita*, on the other hand, is quite certainly no Angiosperm, but a Cryptogam.

These remains, which must obviously have belonged to a fresh-water plant, occur in some profusion in the fissile limestone at the base of the Lias or top of the Rhætics in the neighbourhood of Bristol.[1] The precise beds are called by the Rev. Mr. Brodie "Estheria beds," from the quantity of *Estheria Brodieana*, var. (T. R. Jones), which they contain, while the valves of a species of *Cyclas* are also very abundant with them.[2] The plant remains were determined by Prof. Buckman to belong to the Monocotyledons, and named by him *Najadita* on account of the relationship which he believed they bore to the family of *Najas* or Pond-weeds, and were described and figured in the Quarterly Journal of the Geological Society, 1850, vol. vi. p. 415. The supposed early appearance of this group of Monocotyledons has excited considerable interest, and has frequently been quoted and referred to in works on palæontology and botany. Wishing to re-examine them, I communicated with the Rev. P. B. Brodie, in whose cabinet many of the original specimens are preserved, with the result that a number of them were placed at my disposal.

My first examination convinced me that far from being Monocotyledons, they were cellular Cryptogams of some kind, the supposed rectangular venation being nothing more than the cell walls of the tissue forming the leaf-blades. I next took them to Manchester, where Prof. Williamson kindly looked at them, and without a moment's hesitation pronounced them to be the remains of cellular plants. Since then Mr. Carruthers has examined them, when Mr. Ridley, who has charge of the Monocotyledons, and Mr. Murray, in whose care the Cryptogamic section of the British Museum Herbarium is placed, were also invited to express their opinions, the result being that all these botanists agreed in regarding them as Cryptogams resembling *Fontinalis* in habit. They in fact bear the strongest possible resemblance to these fresh-water mosses, and without wishing to place them definitely in the genus *Fontinalis*, it does appear to me to be useless to seek further among existing plants for their affinities. This group of fresh-water mosses has not previously been included in any fossil flora, and it would indicate a temperate climate, thus corroborating the evidence of the insects associated with it, and that the water was limpid, with a feeble current. I am most pleased to be able to state that Mr. Brodie quite concurs in the transfer of his specimens to the aquatic mosses.[3]

The *Lilia*, *Bensonia*, and other supposed Monocotyledons and

[1] Q.J.G.S. vol. vi. p. 415, 1850.

[2] Mr. Brodie informs me that he regards them as a junction bed between the two formations.

[3] Mr. Brodie has since sent me a capsule from these beds, which appears to belong to the same moss.

Dicotyledons of Buckman[1] seem to be either Cycadaceous or too indistinct to be determinable, and no importance whatever can be attached to their supposed Angiospermous affinities.

Among many specimens lent me by Mr. Brodie, however, is one undoubtedly Monocotyledonous fragment from the Purbeck of Swindon (Plate V. Fig. 2), three millimètres wide, with nine parallel equal longitudinal veins. It has a rush or grass-like appearance, but may possibly belong to an aquatic plant.

The records of some of the supposed early Angiosperms may have escaped me, but some have purposely not been included in this notice, because they are not deserving of mention.

No new types come in during the Lower Cretaceous, and our knowledge of the Angiosperms of this period remains in a most imperfect state. There are still jointed stems and occasional fragments of sword-like leaves, and the important *Dracæna*-like *Eolirion*, of Schenk. I have found rolled pellets of palm-like wood in the Gault at Folkestone, and, as already stated, an organism in the Grey Chalk which Saporta pronounced to be a *Williamsonia*. The most remarkable thing is that not the smallest trace of an Angiosperm has been found in the Wealden deposits, though these appear to have been pre-eminently likely to have preserved such, had they existed. A host of Dicotyledons as well as many of the principal families of Monocotyledons, come in with the Upper Cretaceous, but the relative ages of the beds in which they occur are by no means satisfactorily determined, and, as Floras, they are rather to be grouped with those of the Tertiaries than those of the Wealden, Neocomian and Gault.

The mystery in which the early development of Angiosperms is still shrouded is the more inexplicable, since the presence of a flower-sucking moth in the Solenhofen beds is a well-ascertained fact. From a remark made by Prof. Marsh, at Aberdeen, there is some hope that welcome revelations regarding American Jurassic Angiosperms may reach us ere long. In the meantime I refrain from encumbering this communication with any of the obvious speculations that have occurred to me, and probably to others, as possible explanations of their extreme rarity in præ-Cretaceous deposits. The evidence tends to show that Monocotyledons (?) of some sort existed as far back as the Trias, possessing leaves of the most primitive type, such as we now meet with in *Yucca*, *Dracæna*, etc., and that during the Jurassics decided Monocotyledons, which can be placed in the *Pandanaceæ*, and others with jointed stems like *Gramineæ*, flourished side by side with more problematical plants such as *Williamsonia*. Little more than this can yet be said, though Saporta and Marion bring forward an array of arguments and inferences wherewith to build up a family tree,[2] which if not quite carrying conviction, are certainly highly suggestive, and deserve the most careful consideration.

[1] Murchison and Buckman, Outline of the Geology of Cheltenham, 1845.
[2] Evolution des Phanérogames, Saporta and Marion.

II.—On the Palæontology of the Selachian Genus *Notidanus*, Cuvier.

By A. Smith Woodward, F.G.S.,
of the British Museum (Natural History).

(PLATE VI.)

Among the Selachians of the existing fauna, there are none of greater interest and higher morphological importance than *Notidanus*, *Cestracion*, and the recently-discovered *Chlamydoselachus* from Japanese seas. These are the solitary survivors of once flourishing types, whose immediate congeners are only known to Biological science through the fragmentary remains preserved in the geological record; and the value of the archaic features they present is even further enhanced by the slight information already acquired regarding the geological distribution of their numerous extinct allies.

Hitherto, however, there appears to have been no attempt at a systematic treatment of the Palæontology of the first of these genera, although the Cestraciont and Cladodont types have received a large share of attention. I therefore propose to offer a short account of the present state of knowledge of this subject—summarizing the results of previous research, making known a few interesting fossils that have not yet been described, and adding some general remarks on the extinct congeners of the Notidanidæ, so far as they can be determined from the evidence of detached teeth.

Briefly reviewing the main anatomical features of the living *Notidanus*, in the first place, there are several peculiarities especially worthy of note. The skull is remarkable from its close approach to the amphistylic type of Professor Huxley.[1] Unlike all other living Selachians, the upper element of the hyoid arch is extremely slender and takes no part in the support of the pterygo-quadrate and mandibular cartilages; but this is compensated for by a distinct facette upon the otic process which articulates with the post-orbital process of the chondrocranium.[2] The mandibular and hyoid arches thus most nearly retain their primitive condition, and there is also only a very slight advance upon this stage in *Cestracion*:[3] in this genus, the pterygo-quadrate articulates with the pre-orbital region of the chondrocranium, and the "hyomandibular" is only just becoming worthy of that name. These characters are so important, when taken in conjunction with others exhibited by the same types, that in dividing the Selachii into four great suborders, Prof. Theodore

[1] T. H. Huxley, "On *Ceratodus Forsteri*, with Observations on the Classification of Fishes," Proc. Zool. Soc. 1876, pp. 40–45.

[2] See excellent figures by C. Gegenbaur, "Das Kopfskelet der Selachier" (1872), plate x.

[3] T. H. Huxley, *loc. cit.* p. 42, fig. 8.

Gill[1] regards the Notidanidæ and the Cestraciontidæ as the sole existing representatives of the first two.

Notidanus is also remarkable for the persistence of the notochord. One section of the genus (*Hexanchus*) exhibits this gelatinous rod merely subdivided by transverse membranous septa, while the other (*Heptanchus*) has annular cartilages in the sheath which only show traces of calcification in the region of the tail.[2]

As regards fins, the genus under consideration differs from other Sharks (except *Chlamydoselachus*) in possessing only a single dorsal, without spine, which is placed far back, partly opposite the anal. The latter is well marked off from the caudal. The structure of these locomotory appendages in *Notidanus* is also interesting, but there is much difference of opinion as to the conclusions to be drawn from them. Prof. Huxley has given reasons[3] for regarding the pectorals as of a more primitive type than those of other living Selachians and as most nearly related to the so-called "archipterygium" of *Ceratodus;* while Prof. Mivart[4] is led to dissent entirely from this interpretation, and to look upon it as nothing more than "an ingenious speculation." The latter has also shown (*loc. cit.*) how the basal cartilages of the dorsal and ventral fins, and, to a less extent, those of the anal, have become fused together into a nearly continuous mass,—a fact of considerable significance if, as seems probable, the basals were a parallel series of thin cartilaginous bars in the earliest forms of fin.

Another curious feature of *Notidanus* consists in its possession of more than five gill-openings besides the spiracle, and in this peculiarity it differs from all other living Sharks except the *Chlamydoselachus*. Some of the species have six of these openings and others seven; and most ichthyologists prefer to regard each of these types as constituting a distinct genus, the first named being termed *Hexanchus*, and the second *Heptanchus* or *Heptranchias*. Dr. Günther,[5] however, is inclined to admit no such separation, and as it is quite impossible for palæontological purposes, it cannot be adopted here.

But the points to which the palæontologist is naturally led to devote most minute attention are those relating to the harder structures capable of preservation in the fossil state. And it fortunately

[1] In Jordan and Gilbert's "Synopsis of the Fishes of North America," Bull. U. S. National Museum, No. 16 (1883), p. 967.

[2] See detailed descriptions of C. Hasse, "Das Natürliche System der Elasmobranchier—Besonderer Theil" (1882), pp. 39–52, pls. vi. vii.

[3] *Loc. cit.* p. 50.

[4] St. G. Mivart, "Notes on the Fins of Elasmobranchs," Trans. Zool. Soc. vol. x. (1879), p. 477.

[5] A. Günther, "Catalogue of Fishes Brit. Mus." vol. viii. (1870), pp. 397–399.

happens that in the living Notidanidæ there are very decided differences in the teeth of the various species. It is also true, on the other hand, that the dentition of each individual exhibits a certain variability in its components according to their situation in the jaw; but a careful comparison of actual specimens, descriptions, and figures, appears to reveal a few characters that are practically constant, and suggests the possibility of at least determining detached *side* teeth.

In a typical species like *N. indicus* the upper teeth on and near to the junction of the pterygo-quadrate cartilages have some resemblance to very thick, depressed teeth of *Lamna*, without lateral denticles, but placed upon a fibrous base undivided into radicles. The side teeth exhibit one or two distinct denticles or denticulations in front of the principal cone, and an increasing number of small cones behind this, the latter being larger in proportion to the main cone the more remote is the tooth from the front of the jaw. The mandible exhibits a single symphysial tooth, with three or four laterally directed toothlets on each side, but no median cone; and then follow six nearly similar comb-shaped teeth, both to the right and the left. In these, the principal cone is serrated anteriorly, and the hindermost tooth—as in the upper jaw—shows the principal cone least predominant. At the back of both jaws, there are also minute teeth—diminutive knife-edges of enamel, each upon the characteristic form of base.

Besides the widely distributed species whose dentition has just been described, Dr. Günther recognizes three others in his British Museum Cat. Fishes, and about three more have subsequently been determined in America.[1] Ichthyologists thus distinguish about seven living forms of *Notidanus*, and on referring to their published diagnoses, it appears that at least three features in their dentition are specially looked upon as of specific value. These are (i.) the presence or absence of a median tooth, and the presence or absence of a median cone in such a lower tooth; (ii.) the relative prominence of the principal cone in the mandibular side teeth—whether inconspicuous, proportionately stout, or notably elongated; and (iii.) the character of the denticulations in front of the principal cone of the lower teeth. It is obvious that, of these distinctive features, only the two latter are available to the palæontologist, except on rare occasions; but it is satisfactory to find that the upper teeth apparently exhibit the same specific modifications as the lower—*e.g.* a stout or long cone in the one corresponding to a stout or long cone in the

[1] Jordan and Gilbert, "Fishes of N. America," *loc. cit.*, p. 62: and S. Garman, Bull. Essex Institute, vol. xvi. (1884), pp. 56, 57.

other—and it is thus possible to restore the dentition of some of the extinct types with a considerable approach to accuracy.

Of fossil Notidanidæ, no undoubted traces have hitherto been recorded from beds beneath the Middle Oolite. Münster,[1] it is true, mentions a small tooth from the Lias as belonging to *Notidanus*, but no figure is given, and there is not sufficient proof of the accuracy of the determination. Oppel[2] also makes known another tooth from the Upper Lias of Swabia, which he ventures to name specifically *N. Amalthei*, though evidently recognizing the slenderness of the grounds for this procedure; his figure shows nothing beyond a laterally-compressed cone, and neither this nor the description suffices to distinguish it from the tooth of a large *Oxygnathus*. It is further interesting to note that Tate and Blake[3] have recorded Oppel's species from the Middle Lias of Whitby, and this determination is equally unreliable: the original fossil is said to be preserved in the Whitby Museum, but Mr. Martin Simpson has failed to discover it during a search he has kindly undertaken in response to my inquiries, and I am also indebted to Professor Blake for a reference to his note-books, which likewise afford no definite particulars.

The Oxfordian *N. contrarius* and *N. Münsteri* are thus the earliest species of the genus at present described, and with these we commence an enumeration of the different specific types that appear to be distinguishable upon the evidence of detached teeth.

1. N. CONTRARIUS, Münster.

1843. *N. contrarius*, Graf von Münster, "Beitr. zur Petrefaktenkunde," pt. vi. p. 54, pl. ii. fig. 3.

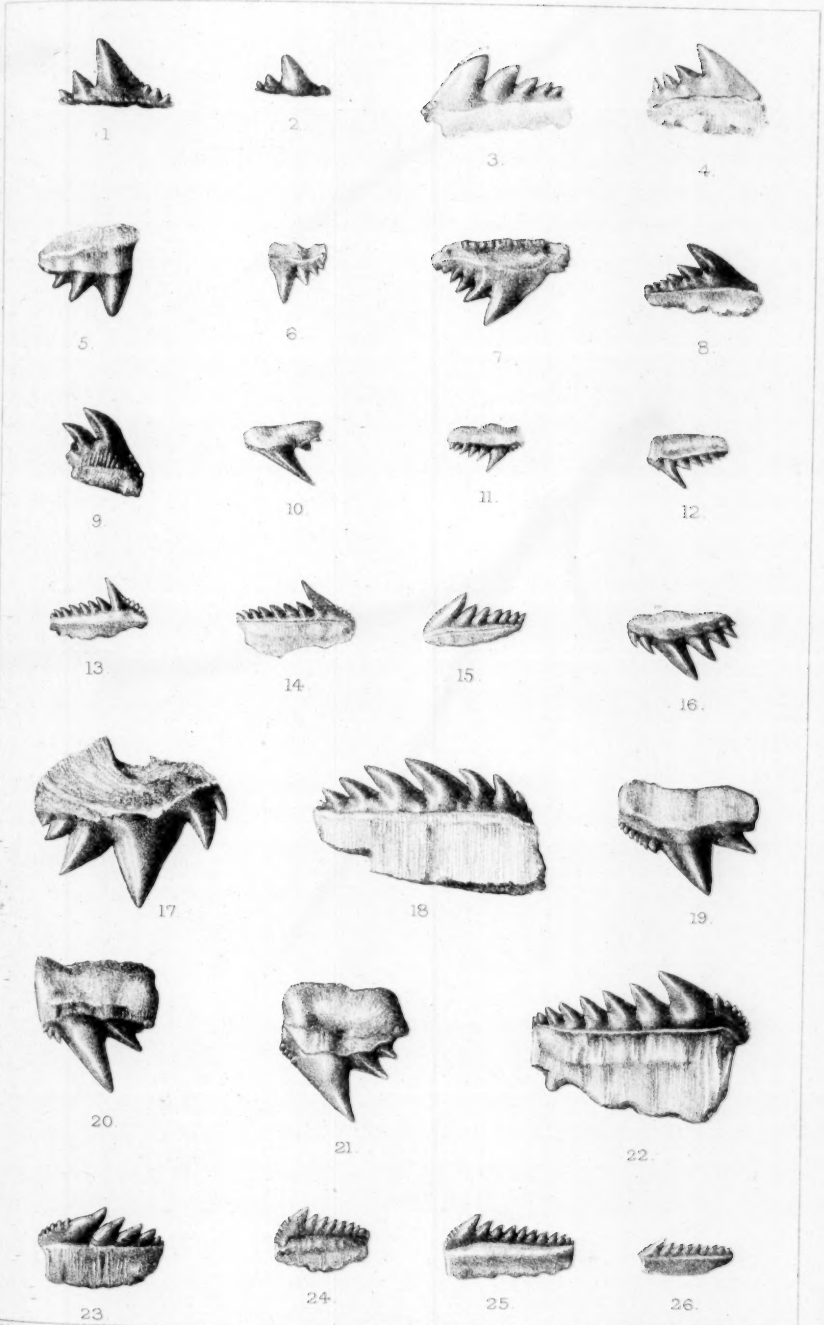
Founded upon a broken tooth from the Lower Oxfordian[4] of Rabenstein, Bavaria. The fossil exhibits two small diverging cones, with a denticle behind, but is much too fragmentary for specific determination, and does not appear to have been recorded since Münster's original description.

2. N. MÜNSTERI, Agassiz.

1843. *N. Münsteri*, L. Agassiz, "Rech. Poiss. Foss." vol. iii. p. 222, pl. 27, figs. 2, 3.

A species founded by Agassiz upon some detached teeth from the Oxfordian (Weiss Jura γ, Quenstedt) of Streitberg, Franconia, and of Randen, Schaffhausen, Switzerland. The type specimen figured exhibits a principal cone destitute of anterior serrations and relatively large both in breadth and height; this is followed by three well-marked secondary cones, closely approximated, and rapidly decreasing in size, and the crown terminates in a small denticulation.

[1] Münster, "Beiträge zur Petrefaktenkunde," pt. vi. (1843), p. 55.
[2] A. Oppel, "Der mittlere Lias Schwabens," Württb. Jahresh. vol. x. (1854), p. 62, pl. i. fig. 1.
[3] Tate and Blake, "The Yorkshire Lias" (1876), p. 256.
[4] This and the other Jurassic horizons have been kindly supplied by Mr. Etheridge.



G.M.Woodward del. et lith.

West, Newman & C° imp.

Fossil Notidanidæ.

There seems to be no undoubted reference to teeth of this type since Agassiz' original description, though the name is mentioned in several lists of Continental Jurassic fossils. The specimens from Schnaitheim figured by Quenstedt as *N. Münsteri* are almost certainly referable to a distinct form next to be considered.

3. N. EXIMIUS, Wagner. Pl. VI. Figs. 3—5.

1849. *N. Münsteri*, Beyrich and Frischmann, Zeitschr. Deutsch. Geol. Gesell. vol. i. p. 436, pl. vi.
1852. ,, ,, F. A. Quenstedt, "Handb. Petr." p. 167, pl. 13, fig. 4.
1858. ,, ,, F. A. Quenstedt, "Der Jura," p. 662, pl. 96, figs. 33, 34.
1861. *N. eximius*, A. Wagner, Abh. k. bayer. Akad. d. Wiss. cl. ix. vol. ix. pp. 292–296, pl. iv. fig. 2.

The Lithographic Stone (Lower Kimmeridgian) of Bavaria is the only deposit that has hitherto yielded remains of *Notidanus* other than detached teeth. But from this fine-grained rock at least three comparatively perfect fishes have been described, in addition to one other fragment of the caudal extremity. Of these, the finest specimen was figured by Beyrich and Frischmann, *loc. cit.*, in 1849, and the subsequent studies of Dr. Andreas Wagner resulted in its being separated from all other known species under the name of *N. eximius*.

The important fossil just referred to was obtained from the quarries of Eichstädt, and is complete with the exception of the tip of the tail: it indicates an original length of about nine feet, and exhibits a very definite outline, owing to the presence of plentifully scattered shagreen granules in the skin. The head is rounded and obtuse in front, and a considerable number of teeth are exhibited in the region of the mouth. The pectoral fins are evidently larger than the ventrals, and the anal is small compared with the dorsal; the latter is almost entirely in advance of the anal, although appearances may be deceptive owing to pressure during fossilization. But the most remarkable character displayed in this specimen is the presence of well-marked annular cartilages in the sheath of the notochord. These have been carefully studied by Dr. Hasse,[1] of Breslau, who has shown that they agree in microscopical structure with those of the living *Heptanchus*; and this Kimmeridgian form is thus the only fossil species hitherto discovered that it has been possible to refer to the correct subgenus. The vertebral rings in the caudal region are further apart than in the more anterior portions of the body.

The two other specimens of *Notidanus* from the Lithographic Stone are of small size, not exceeding 4½ inches in length, and are regarded by Wagner as probably the young of the species under consideration. No figures have been published, but a plaster cast of one of these immature fishes is exhibited in the British Museum.

A group of the teeth of *N. eximius* are figured by Beyrich and Frischmann, and Wagner also represents a solitary example. The drawings of the Eichstädt fossil, however, do not appear to illustrate the variation of the dentition in different parts of the mouth, nor do the authors offer any particular observations upon this point. In

[1] C. Hasse, "Natürl. Syst. Elasm.—Besond. Theil," pp. 51, 52, pl. vii. figs. 23–25.

the ordinary lateral teeth, the principal cone is destitute of serrations on its anterior border, and is followed by three (or sometimes four) much smaller cones. These teeth chiefly differ from *N. Münsteri* in the wider interspaces between the successive cones. They are also somewhat larger, and the apex of each cone occasionally exhibits a slightly hooked appearance.

Other teeth of the type just described are met with in the Upper Corallian beds of Schnaitheim, Würtemberg, and were originally figured by Quenstedt (*loc. cit.*) under the name of *N. Münsteri*. Wagner makes a brief allusion to these at the end of his description of *N. eximius*, and hints that they may possibly belong to his newly determined species. The National Collection contains a good series of specimens from the same deposit, which appear to leave no doubt of the correctness of this identification, and three of these form the subjects of Figs. 3–5. The teeth exhibit considerable variation in size—from one to two centimetres in length—and this may be due not only to age, but also to differences corresponding to the various parts of the jaw. All, however, are characterized by wider interspaces between the cones than is the case in *N. Münsteri*. In teeth that are probably from the front region of the mandible (Figs. 3, 4), the principal cone is relatively longer and less oblique than in those further back; while in anterior teeth of the upper jaw, the principal cone is still more prominent and placed erect upon the base. Fig. 5 represents one of the latter type, and the original of fig. 34, pl. 96, in Quenstedt's "Jura," is probably another from nearly the same situation. Of lower teeth, the other illustrations of Quenstedt are evidently characteristic examples, and Fig. 3 is a drawing of the largest tooth in the British Museum Collection; this specimen—like two others, Nos. 22489 and P. 4708—is remarkable on account of the oblique abrasion of the apex of the principal cone, which appears to have been produced during the life of the animal. The same figure also shows a slight crimping at the lower part of the anterior edge of the tooth; and fig. 33, pl. 96, of Quenstedt's "Jura," likewise exhibits this feature upon a greater extent of the border, but there is no definite denticulation.

It is interesting to add that Wagner further records a single tooth of *N. eximius* from Daiting, and another from the Lithographic Stone of Nusplingen, Swabia.

The upper tooth shown in Fig. 6 was also obtained from the Schnaitheim beds, but it appears scarcely referable to *N. eximius*, and must remain at present specifically undetermined.

4. N. Wagneri, Agassiz, sp.

1843. *Aellopos Wagneri*, L. Agassiz, Rech. Poiss. Foss." vol. iii. p. 233.
1861. *Notidanus Wagneri*, A. Wagner, Abh. k. bayer. Akad. d. Wiss. cl. ix. vol. ix. pp. 296–299.

In the volume of the "Neues Jahrbuch" for 1836, p. 581, Count Münster briefly recorded a Selachian fossil from the Kelheim Lithographic Stone under the name of *Aellopos elongatus*. It exhibited nothing more than the hinder region of the body, and its affinities

were thus somewhat problematical, but the distinguished palæontologist just mentioned felt justified in regarding it as the type not only of a new species, but also of a new genus. Some years later, when preparing his classical work on Fossil Fishes, Agassiz confirmed Münster's original determination, and founded a second species of *Aellopos*—termed *A. Wagneri*—upon another specimen preserved in the Munich Museum. This likewise exhibited only the hinder region of the body, but the great relative size of what was then considered to be the second dorsal fin, and the distinctly calcified vertebral rings, were quite sufficient to separate it from all fossil sharks at that time known. No figures were published, however, and Agassiz' short notice embodied all available information until 1861, when Dr. Andreas Wagner was engaged in investigating the fish-fauna of the Solenhofen Stone, and succeeded in elucidating the problematical fossil by a reference to the magnificent specimen of *Notidanus eximius*, figured by Beyrich and Frischmann. His researches led to the conclusion that Münster's *A. elongatus* was really a *Squatina* (or an allied genus), and that Agassiz' *A. Wagneri* might be referred with equal certainty to the genus *Notidanus*. The considerable dimensions of the supposed "second" dorsal fin were thus no longer remarkable, and the comparatively advanced condition of the vertebral column was recognized as quite similar to that of the complete specimen just quoted. Some minor differences are sufficient to distinguish *N. Wagneri* from *N. eximius*, and among others, may be mentioned the relatively greater length of the dorsal fin: the vertebræ are also longer, and wide interspaces between them do not begin to appear before the middle of the tail, whereas in *N. eximius* this character is obvious quite at its commencement.

5. N. INTERMEDIUS, Wagner.

1861. *N. intermedius*, A. Wagner, *loc. cit.* p. 299, pl. iv. fig. 3.

A species founded upon a single tooth from the Lithographic Stone of Mühlheim, near Solenhofen, and characterized by the large size of the denticulations in front of the principal cone, which is thus placed not far in advance of the middle of the tooth. Behind the principal cone are five smaller ones.

As Wagner observes, this determination is merely provisional, for the dentition of *N. Wagneri* is at present wholly unknown, and the form of tooth in question may eventually prove to belong to the latter species.

6. N. HÜGELIÆ, Münster.

1843. *N. Hügeliæ*, Graf von Münster, "Beiträge zur Petrefaktenkunde," pt. vi. p. 54, pl. i. fig. 5.
1852. ,, ,, (?) F. A. Quenstedt, "Handbuch der Petrefaktenkunde," p. 167, pl. 13, figs. 5, 6.
1858. ,, ,, F. A. Quenstedt, "Der Jura," p. 519.

This species was founded by Münster upon a broken tooth from the Corallian of Gammelshausen, near Boll, Würtemberg. The specimen exhibited a large principal cone (without anterior serrations) followed by two small cones of about one-third the size of the first.

The originals of the figures in Quenstedt's "Handbuch" are very much smaller than the type specimen, and are characterized by the presence of anterior serrations; it is doubtful, indeed, whether they are truly referable to this form.

7. N. SERRATUS, Fraas. Pl. VI. Fig. 7.

1855. *N. serratus*, O. Fraas, Württemb. Jahresh. vol. ix. p. 98.
1858. ,, ,, F. A. Quenstedt, "Der Jura," p. 784, pl. 96, fig. 44.

This species was originally named by Fraas, but does not appear to have been completely defined before the publication of Quenstedt's work on the Jura. The last-mentioned palæontologist records a group of about 14 teeth, naturally associated, and figures one of the most typical forms. This, as a Jurassic type, is remarkable on account of the number of distinct cones that make up its crown, and the prominence of the sharp denticulations on the front edge of the principal cone; the latter is comparatively broad and long, and is succeeded by seven minor cones, of which the anterior is very much the largest. The species occurs in the Corallian of Nusplingen, Swabia.

A detached specimen in the British Museum (No. 35667), obtained by the late Mr. Bean from the Oxford Clay of Scarborough, agrees so closely with the tooth of this species figured by Quenstedt that it cannot be separated on present evidence. The fossil in question is shown of the natural size in Fig. 7, and is in an almost complete state of preservation. The principal cone of the crown is relatively very large, and is succeeded by five secondary cones, while at its base in front there occur three closely approximated denticles, the first being of considerable size. Of the secondary cones, the most anterior is directed sharply backwards and makes a wide angle with the posterior edge of the principal cone; it is nearly a third larger than that immediately following, and the remaining three are quite small. The base-line of the crown is arched, and the lower border of the root has a somewhat crimped appearance. This is evidently a tooth of the upper jaw, and the respects in which it differs from Quenstedt's figure are precisely those in which the upper teeth of living species differ from the lower.

8. N. DAVIESII, sp. nov. Pl. VI. Fig. 8.

1871. *Hybodus polyprion*, J. Phillips, "Geology of Oxford," p. 305, pl. xii. fig. 18.

The scarcity of remains of *Notidanus* in the Jurassic rocks of Britain appears somewhat remarkable when it is remembered how frequently they have been recorded on the Continent: and in addition to the Scarborough tooth already described, I have only succeeded in meeting with two other specimens.[1] These were erroneously referred to *Hybodus* by Professor Phillips, *op. cit.*, and they have been kindly pointed out to me by Mr. William Davies, who recog-

[1] Besides others already named, I have also to thank the following friends and correspondents who have kindly assisted me in the search for Jurassic Notidanidæ:—Mr. E. T. Newton, of Jermyn Street; Mr. T. Roberts, of the Woodwardian Museum, Cambridge; Mr. H. M. Platnauer, of the York Museum; Mr. H. J. Moale, of the Dorset County Museum; and Mr. H. E. Quilter, of Leicester.

nized their true affinities some years ago when identifying fossil vertebrata in the Oxford Museum; I am also indebted to the kindness of Professor Prestwich for the opportunity of studying and publishing a further notice of the original teeth.

The specimens in question were obtained from the Oxford Clay of St. Clement's, near Oxford, and as they cannot be safely identified with any form at present known, I propose to apply to the most satisfactory tooth (Fig. 8) the provisional name of *N. Daviesii*: the second fossil (Fig. 9) may possibly be a variety of the same species, but this is at present uncertain. In the type specimen shown in Fig. 8, the principal cone is relatively large, both in breadth and height, and is destitute of serrations on its anterior border. This is followed by four rapidly diminishing secondary cones, and the crown terminates in a minute denticulation. The apices and edges of all the cones are remarkably sharp, and the base is short and thick compared with that of the majority of later species. The second tooth (Fig. 9) has a very peculiar form, and consists merely of two backwardly curved cusps, though other small ones may have been broken away behind. The lower part of the anterior edge of the principal cone is crimped, and the enamelled sides of the crown exhibit vertical wrinkles suggestive of those of *Hybodus*.

N. Daviesii appears to approach *N. Münsteri* more closely than any other, but it is easily distinguished from this species by the different relative proportions of the principal and secondary cones.

9. N. MICRODON, Agassiz. Pl. VI. Figs. 10—15.

1822. Tooth of *Squalus?* G. A. Mantell, "Fossils of South Downs," p. 227, pl. xxxii. fig. 22.
1843. *N. microdon*, L. Agassiz, "Rech. Poiss. Foss." vol. iii. p. 221, pl. 27, fig. 1, pl. 36. figs. 1, 2.
1843? ,, ,, H. B. Geinitz, "Schichten und Petrefakt. d. sächsisch.-böhm. Kreidegeb." p. 38, pl. ix. fig. 2.
1846. ,, ,, A. E. Reuss, "Verstein. d. böhm. Kreideform." pt. ii. p. 98, pl. xlii. fig. 8.
1850. ,, ,, F. Dixon, "Geol. and Foss. Sussex," pl. xxx. fig. 30.
1878. ,, ,, A. Fritsch, "Rept. u. Fische d. böhm. Kreideformation," p. 12 (woodcut).

Almost all the teeth of *Notidanus* met with in the Upper Cretaceous formations are referable to a single widely-spread species, *N. microdon*. This is a small form with a total number of five to nine distinct cones in its side teeth, each of these being slender and sharply pointed, and the principal cone usually much elongated compared with the remainder: there are also well-marked denticulations on the front edge of the crown.

On examining a large series of specimens, such as that available for study in the British Museum, considerable variations are at once apparent; but there are scarcely any discrepancies in size, and the presence of intermediate forms renders it quite impossible to recognize more than a single specific type. Some (Fig. 10) are obviously from the front of the upper jaw, and consist only of a single large cone, with one or two small denticles behind; while the short teeth, with prominent principal cone and 4—5 secondary cones (*e.g.* Figs.

11, 12) may be referred with almost equal certainty to situations in the upper jaw somewhat further back. The elongated teeth, which belong to the sides of the lower jaw—and perhaps partly to the upper—usually have the principal cone relatively prominent (Figs. 13—15), though in one or two examples such is not the case. The anterior serrations are mostly fine and numerous, but in a few instances (of upper teeth) they are reduced in number and increased in size.

Of British Cretaceous strata, the various divisions of the Chalk appear to yield the most abundant remains of *N. microdon*, although the Cambridge Greensand also affords a considerable number. The National Collection comprises specimens from Maidstone, Burham, and Charing in Kent; Lewes and other localities in Sussex; Guildford in Surrey; and Swaffham and Norwich in Norfolk.

10. N. LANCEOLATUS, sp. nov. Pl. VI. Fig. 16.

In the Egerton Collection of the British Museum there is a single upper tooth of *Notidanus* (p. 1227) from the Gault, which it appears impossible to identify with any species hitherto described. It is much larger than the corresponding teeth of *N. microdon*, and as its most conspicuous feature consists in the comparatively long and narrow form of the cones, I propose to distinguish this type of tooth by the provisional name of *N. lanceolatus*. The principal cone is relatively prominent, and is preceded by two very long denticles: there are three secondary cones, and the crown terminates in a minute denticulation. The great development of the anterior denticles renders it likely that the lower teeth were somewhat similar to those of *N. pectinatus*, Ag., but the latter is a much smaller species.

11. N. PECTINATUS, Agassiz.

1843. *N. pectinatus*, L. Agassiz, "Rech. Poiss. Foss." vol. iii. p. 221, pl. 36, fig. 3.

A species founded upon a tooth from the Chalk, about the size of *N. microdon*, but especially differing from that form in the conversion of the anterior serrations of the crown into a series of distinct denticles. This type of tooth appears to be extremely rare, and I have not seen any examples.

12. N. DENTATUS, sp. nov. Pl. VI. Figs. 17, 18.

Among the Selachian remains in a collection of New Zealand fossils sent by Dr. Hector to the British Museum in 1876, there are two teeth from the Cretaceous of Amuri Bluff which are undoubtedly referable to the genus *Notidanus*. In several respects they differ from one another to a considerable extent, but an acquaintance with the dentition of living Notidanidæ can leave no doubt that they belong to a single specific type, and that the one is an upper tooth, while the other formed part of the mandibular series.

The lower tooth, which is shown of the natural size in Fig. 18, exhibits three small denticles in front of the principal cone, the first being the largest and having a recurved apex, the second slightly smaller with straight but backwardly-directed point, and the third

very much more minute. Behind the principal cone, which is scarcely more robust than that immediately following, there are ranged three other cones, of gradually diminishing size; and posterior to these a minute denticulation is visible.

In the upper tooth (Fig. 17) the principal cone appears more definitely contrasted with the others. In front there are two distinct denticles, the first being three times the size of the second, and the principal cone itself is placed almost vertically with respect to the base-line of the crown, although its anterior edge has a much less abrupt slope than the posterior. Behind this, there are three other cones rapidly decreasing in dimensions; the first, somewhat inclined backwards and three-fourths the size of the principal cone; the second, backwardly directed at a corresponding angle, but only about one-third as large as the first; and the third, a minute, broad acuminate denticle. Though now imperfectly shown, the base-line of the crown was obviously arched, and the remains of the root indicate the usual configuration and robust proportions of an upper tooth.

On considering this assemblage of characters, the substitution of distinct denticles for the ordinary serrations on the anterior edge of the principal cone in the lower tooth, is obviously the most striking feature; and hence it is proposed to distinguish the present modification under the specific name of *N. dentatus*. The only other fossil *Notidanus* that exhibits this peculiarity is the very rare *N. pectinatus* from the English Chalk, but this is a much smaller species, and differs in possessing a longer series of cones behind the principal. Among existing forms, however, one appears to be remarkable for its possession of the very same character.[1] This is the little *N. pectorosus* from the seas off the Patagonian coast, and Mr. Garman's description[2] of the lower tooth of this form agrees almost precisely with the particulars given above; he states that each tooth "has one to two small, followed by four moderate-sized, cusps, the anterior of the four being little if any longer than the other three; and, in cases, there is also a small cusp on the posterior portion of the base." Indeed, in the absence of figures, *N. dentatus* can only be distinguished from *N. pectorosus* by the presence of one more anterior denticle in its teeth, and by its relatively gigantic size—for the Patagonian species is only 16 inches in total length.

If subsequent researches tend to substantiate the latter statement, the fact becomes of unusual interest, since it was from the same deposit at Amuri Bluff that Mr. E. T. Newton, a few years ago,[3] made known a tooth of *Callorhynchus*, differing only in minor points from *C. antarcticus* of the present southern seas. This living Chimæroid ranges through the same ichthyological province as Mr. Garman's new species of *Notidanus*, and the association of two extinct

[1] The lower teeth of *N. cinereus* also exhibit some approach to this character.

[2] S. Garman, "A species of *Heptranchias* supposed to be new," Bull. Essex Institute, vol. xvi. (1884), pp. 56, 57.

[3] E. T. Newton, "On Two Chimæroid Jaws from the Lower Greensand of New Zealand," Q. J. Geol. Soc. vol. xxxii. (1876), pp. 329, 330, pl. xxi. figs. 6—9.

allies in a formation said to be of Cretaceous age in New Zealand is a very remarkable circumstance.[1]

13. N. SERRATISSIMUS, Agassiz. Plate VI. Figs. 23–26.

1766. *Dens Squali*, G. Brander, "Fossilia Hantoniensia," fig. 111.
1843. *N. serratissimus*, L. Agassiz, "Rech. Poiss. Foss." vol. iii. p. 222, pl. 36, figs. 4, 5.
1870. „ „ F. Römer, "Geologie von Oberschlesien," p. 379, pl. 48, fig. 1.

This species was founded upon two teeth from the London Clay of Sheppey, said to be preserved in the collection of Dr. Bowerbank, but not now recognizable among the specimens acquired by the British Museum. The teeth are comparatively small—the largest I have examined not attaining a length of two centimetres—and the total number of cones appears to vary from five to ten, according to the situation in the mouth. The principal cone is only slightly longer than the first of those immediately following, but it is somewhat more robust and has its anterior edge much produced forwards and strongly indented with a series of regular serrations throughout half its length. The apices of all the cones are more or less blunt.

Fig. 23 represents a typical tooth of this species, such as was known to Agassiz. I have not succeeded in satisfactorily determining whether it appertains to the upper or the lower jaw; but in addition to this form the London Clay also yields a number of more elongated teeth, which are undoubtedly referable to the mandibular series. An adult specimen is preserved in the Museum of Practical Geology, and there are several immature examples in the British Museum. Three of the latter are shown in Figs. 24–26, and, except in size, they only differ from the adult in being either destitute of anterior serrations or exhibiting very delicate traces of them.

In England, *N. serratissimus* appears to be almost exclusively confined to the London Clay, rarely occurring in the Middle Eocenes of Barton and Bracklesham. On the Continent, however, Dr. Römer has described (*loc. cit.*) a similar tooth from the Lower Miocene of Zabrze, Silesia.

14. N. PRIMIGENIUS, Agassiz. Pl. VI. Figs. 19–22.

1843. *N. primigenius*, L. Agassiz, "Rech. Poiss. Foss." vol. iii. p. 218, pl. 27, figs. 4–8, 13–17.
1843. *N. recurvus*, L. Agassiz, *ibid.* p. 220, pl. 27, figs. 9–12.
1849. *N. primigenius*, R. W. Gibbes, Journ. Acad. Nat. Sci. Philad. ser. 2, vol. i. p. 195, pl. xxv. fig. 95.
1852. „ „ A. Quenstedt, "Handb. Petrefakt." p. 167, pl. 13, fig. 3.
1858. „ „ J. Probst, Württb. Jahreshefte, vol. xiv. pp. 124–127.
1877. „ „ R. Lawley, Atti Soc. Toscana Sci. Nat. pp. 66–68, pl. i. figs. 1–5.
1877. *N. recurvus*, R. Lawley, *ibid.* pp. 69, 70, pl. ii. fig. 1.
1879. „ „ J. Probst, Württb. Jahresh. vol. xxxv. pp. 162, 163, pl. iii. figs. 12–17.

[1] In addition to *Notidanus dentatus*, the National Collection also comprises three teeth of *Oxyrhina* and one of *Odontaspis* from these beds; the former bear a very close resemblance to the common *O. Mantelli* of the European Cretaceous, though there are not sufficient materials to establish their identity; and the *Odontaspis* is indistinguishable from the well-known *O. subulata* of the same age.

1879. *N. primigenius*, J. Probst, *ibid.* pp. 158–162, pl. iii. figs. 1–5.
1885. ,, ,, F. Noetling, Abh. Geol. Specialk. Preussen u. Thüring. Staaten, vol. vi. pt. 3, pp. 17–19, pl. i. figs. 4, 5.

Among the fossil Notidanidæ, the dentition of *N. primigenius* appears to be more completely known than that of any other. Lawley in Italy, and Probst in Würtemberg, have both contributed to its elucidation, and though Agassiz stated that during his elaborate researches he had only succeeded in determining lower teeth, there can be little doubt now that he also figured some belonging to the upper series. It seems probable that fig. 13 of plate 27 in the "Poissons Fossiles" really represents a tooth of the upper jaw; and if the originals of figs. 4–8 are correctly associated with the others (which is perhaps questionable), these likewise must be referred to a similar situation: it is almost certain, too, that the so-called *N. recurvus* is an upper tooth of the same species.

In the mandibular teeth of *N. primigenius* (Fig. 22), the principal cone is only slightly longer and more robust than that immediately following, but the lower part of its anterior edge is much produced forwards and bears a number of small serrations, which decrease in size from above downwards. The secondary cones gradually diminish as they approach the hinder end of the crown, and of these there are usually five or six. The median lower tooth is not yet certainly known, although both Probst and Lawley venture to claim its discovery. The former figures it as having a median cone, while the latter represents it as possessing only lateral cones—so that as it is impossible for these to belong to the same species, neither determination can be accepted as correct until more satisfactory evidence of association is forthcoming.[1]

(*To be continued in our next Number.*)

III.—Notes on Jurassic Brachiopoda.

By S. S. Buckman, F.G.S.

THE following notes relate to two Brachiopods—a *Rhynchonella* and a *Terebratula*—figured by the late Dr. Davidson in his last plates in the Palæontographical. Of the first a change of name is necessary; of the second, I consider that the identification needs revision, and that it deserves a separate name. Both species are from the Inferior Oolite.

Rhynchonella liostraca, S. Buck.

1883. *Rhynchonella bilobata*, S. Buck., Brachiopoda Inf. Ool. Dorset, Nat. Hist. Soc. Proc. vol. iv. p. 50.
1884. ———— *bilobata*, Davidson, Appendix to Supplement Brachiopoda, Palæontographical Soc. Proc. vol. 38, plate 19, figs. 18, 19.

Having given the above references, there can exist no doubt as to the species intended; but having subsequently found that the name *bilobata* had been used for a species of *Rhynchonella* previous to my

[1] In his second paper (1879) Probst confirms his original determination (1858) and suggests that Lawley's fossil probably belongs to *N. gigas* or *N. Meneghinii*.

applying it to this one, I take an early opportunity of altering the name of the species to *Rhynchonella liostraca.*

The late Dr. Davidson, whose kind assistance I have so often experienced, gave capital figures in his Brachiopoda (reference quoted above) of this most peculiar species. In the Inferior Oolite of England there is not as far as is known any species that at all approaches to this one in character, or with which it could possibly be confounded. The complete absence of any ribs, except just at the junction of the valves at the base, has induced me to give it the name of *liostraca.* It is an extremely rare form, and has only been met with at a few places. There are probably not more than eight or nine examples known. Its horizon is the *Sowerbyi* zone at one or two quarries near Bradford Abbas in Dorset, and near Corton Denham in Somerset.

The late Dr. Davidson, under the name *bilobata,* figured the types of this species, both of which were collected by myself. The one represented in fig. 18 I presented to Dr. Davidson, and it is now probably in the Natural History Museum.

The only species at all resembling this one with which I am acquainted is *Rhynch. trigona,* Quenstedt, Brachiopoda, plate 40, fig. 71; but, as I stated in first describing this species, it differs from *Rh. trigona* in having a well-marked deepish furrow in dorsal valve, no ribs at all, but only notched at base, and dorsal valve convex from beak to base.

Terebratula euides, S. Buck.

1883. *Terebratula dorsoplana* Buck., non Waagen. Proc. Dorset Nat. Hist. Soc. vol. iv. page 14.

1884. *Terebratula Fleischeri?* Davidson, non Oppel. Brachiopoda, Palæont. Soc. Proc. Appendix to Supplement, plate 19, figs. 4–4*a*, page 262.

This peculiar biplicated species has been a considerable puzzle. As can be seen, I referred it to *Terebratula dorsoplana,* Waagen;[1] but Dr. Davidson, in the course of correspondence with Dr. Waagen on the subject, came to the conclusion that this identification was incorrect, a view in which I now also concur. In fact, a comparison of the beaks of the specimens as represented by Waagen and Davidson will show the difference. The foramen in Waagen's figure being very small, separated from the umbo, and showing the deltidium, while this species possesses a large circular foramen almost touching the umbo. One point that is not quite brought out in Davidson's figure is the rather pinched appearance of the beak, in consequence of rather prominent beak ridges and a carina down the middle of the ventral valve.

Dr. Davidson referred this species to *Terebratula Fleischeri,* Oppel, but with this I cannot agree. Dr. Oppel[2] took as the type of his *Tereb. Fleischeri* the specimen figured by Davidson, Jurassic Brachiopoda, Pal. Soc. pl. xiii. fig. 7, which is an elongated slightly biplicated shell, much longer and narrower than the one under discussion, and it lacks the peculiar beak ridges and pinched appearance of the beak.

[1] Geog. Pal. Beiträge, plate 31(8), fig. 7.

[2] Oppel, Juraformation, page 497.

Our species has often been confounded with *Tereb. perovalis*, Sow., and *Tereb. Stephani*, Davidson. From the first it is easily distinguishable by its larger plications and its carina down the larger valve, but these characteristics unite it with *Tereb. Stephani*, from which, however, it may be distinguished by a shorter, less incurved beak, and its plications not extending so far up the valves. The characteristic beak ridges as mentioned before are not possessed by either of these other two species.

Terebratula euides is rather rare. It has been found chiefly in a quarry about two miles from Sherborne, in Dorset, in a sandy bed at the very bottom of the Murchisoniæ zone, along with *Terebratula simplex*, Buck., also at one or two other places near Sherborne. It is somewhat variable in width, and the edges of the valves are generally slightly thickened by lines of growth. I take as the type of this species Davidson's figure, Brachiopoda, Pal. Soc., Appendix to Supplement, plate 19, figs. 4, 4*a*, which are drawn from a specimen in my collection.

This species is frequently longer and narrower than the specimen figured by Davidson, sometimes, but rarely, wider. The folds are also slightly variable.

IV.—The Igneous Rocks of Stanner.

By Grenville A. J. Cole, F.G.S.,
Demonstrator in the Geological Laboratory, Normal School of Science and Royal School of Mines.

THE area near Old Radnor marked by invitingly igneous colouring on Sheet 56 S.E. of the Geological Survey Map deserves attention from more than a petrographic point of view. Murchison, in his "Silurian System," has extolled the charms of the surrounding scenery, and the Rev. W. S. Symonds has repeated this admonition to the tourist. The borderland is in truth here eminently picturesque, from the great escarpment of the Ludlows to the high moor of Radnor Forest, the very stratified deposits yielding singular variety of form. The present paper, however, deals merely with one ridge, called Stanner Rock, comparison being occasionally made with its rival, Hanter Hill, from which it is divided only by a narrow vale.

Murchison[1] in 1839 compared the masses composing both these hills to the "hypersthene" rocks of Loch Coruisk, and stated that a variety of greenstones and "felspar rock" were also to be found. The differences, indeed, between specimens obtainable within short distances of one another may account for the fact that on the Survey Map Hanter Hill is coloured as syenite and Stanner Rock as greenstone; whereas Murchison clearly recognized the close relations of the main masses of the two. Dr. Callaway has also touched on the constitution of these hills when dealing with the Pre-Cambrian rocks of Shropshire,[2] and mentions a compact grey felstone as occurring in the centre of the ridge of Stanner Rock.

It is, indeed, at once apparent when one faces the bold cliff which

[1] Silurian System, p. 318. [2] Quart. Journ. Geol. Soc. vol. xxxv. p. 660.

terminates Stanner Rock that the dark mass is traversed by pale intrusive veins of a very different nature; and an examination of the "greenstone" itself reveals a number of dykes and veins of every variety of grain, reminding one of those cutting through the gabbros in the mountains round Coruisk. No true lavas or scoriaceous products remain about the flanks of Stanner, as about Corndon in the north or the Carneddau farther west; we have to deal largely with crystalline materials, which divide themselves at the outset into a more acid and a more basic series. The former, clearly intrusive in the latter, marks the later stages of eruption.

With the relations of these masses to the surrounding deposits I am not as yet prepared to deal. Murchison's prediction that igneous intrusions underlie the altered Woolhope of Nash Scar [1] has not, so far as I am aware, been verified, and evidence of the penetration of this crystalline limestone by igneous veins is wanting at Brook Quarry and Yat Hill. I have failed to find satisfactory junctions between Stanner and Hanter Hill; but may add that I have not found pebbles from these hills in the ancient conglomerate of Old Radnor, which underlies the Woolhope Limestone. It is yet uncertain whether the local alteration can be attributed to faulting and to crushing down against hard earlier igneous masses, or whether it is due, as Murchison held, to the intrusion of those masses in times later than Silurian.

I. The Acid Series.

The most highly crystalline member of this series is a pale pink-grey pegmatite—the word being employed in its original sense [2]—which passes from a well-developed graphic granite through finer varieties to a practically micropegmatitic form. This gradation is beautifully seen on the edge of a vein in Stanner cliff, of which a microscopic section has been prepared; where the cooling has been fairly rapid, along the line of junction with the more basic rock, a selvage of minuter graphic structure occurs, graduating off in a distance of 3 millimetres into the normal coarser form (Fig. 1).

This graphic granite is best developed in veins, not many inches wide, on the southernmost summit of Stanner Rock. Under polarized light the felspar presents the microcline structure, and extinguishes—as one would have inferred from its cleavage-surfaces on the rock-mass—uniformly over considerable areas. The areas of entangled quartz show similar optical connexion, as is the case in so many pegmatites, as though we dealt, not with isolated inclusions in a felspar, but with a complex intergrowth of large quartz and felspar crystals. Some portions exhibit a lamellar arrangement of the two constituents; but this appears to have no relation to proximity to the edges of the vein.

The rock is much cracked and faulted, minute bands of fault-rock appearing in microscopic sections. Hornblende prisms, and perhaps tourmaline, occur in a subordinate manner.

The less crystalline members of the Acid series are found in

[1] See "Siluria," 5th edition, p. 108.

[2] Haüy, Traité de Min. 2nde édit. tome iv. p. 536. "De πηγμα, c'est-à-dire renfermant des pièces qui sont comme fichées dans une matière principale."

several dykes crossing the ridge approximately from east to west. In the hollow north of the pegmatite summit there is a considerable development of grey-white and compact felsite, which, from its frequent appearance at the surface, must form a great part of the centre of the hill. In section this rock is seen to contain scattered porphyritic crystals of quartz, a few plagioclase felspars, and irregular patches of fibrous hornblende, which is to all appearance secondary. Numerous small green prisms, often chloritized, are associated with the matrix, which consists of closely-set spherulites, often formed about minute felspars, the structure being only revealed by polarized light.[1] The radial lines of the spherulites are

Fig. 1.—Section showing Junction of Pegmatite and "Diabase," Stanner Rock. × 7.
Fig. 2.—Section of Quartz-Felsite, Stanner Rock, showing corroded quartz and felspar microlite, serving as centres to spherulites. × 70.
Fig. 3.—Section of Augite-Diorite ("Diabase"), Stanner Rock, showing intergrowth of biotite and augite. × 70.

[1] Very similar rocks from eastern Victoria have been described by Mr. Howitt under Rosenbusch's name of Quartz-granophyrite ("The Rocks of Noyang," Trans. Roy. Soc. Victoria, 1883).

brought out distinctly, but, in place of the formation of a black cross, extinction occurs in two, three, or more sectors at a time, which yield coloured polarization in intermediate positions. This points to secondary crystallization having set in, with the usual passage from a glassy or cryptocrystalline to a microgranular condition. Just as the most detailed structures of the original glass, down to the forms of the minute included crystallites, are preserved in the secondary granules of our ancient rhyolites, so here the spherulitic form and structure remain, in spite of more complete crystallization of the mass. Under higher powers the polarization-effects of the sectors are themselves seen to be complex. A delicate feathery structure has developed, sometimes in pinnate diverging lines, sometimes as a mere network, and the areas into which the spherulite has divided have often become thus minutely pegmatitic. The network commonly extinguishes in one position, while the interspaces extinguish in another—a point best observed when magnified some 400 diameters.

MM. Fouqué and Lévy have figured[1] a quartz-porphyry from near Saulieu, Côte-d'Or, which is almost the precise counterpart of the felsitic rocks of Stanner. They find in the spherulites surrounding porphyritic and corroded crystals of quartz a network that extinguishes simultaneously with the pre-existing central crystal; a complete predominance of this material in the spherulite gives rise to what they have termed *Quartz globulaire*. The micropegmatitic structure of these authors appears to give similar effects, as if the radiating lines of quartz were an attempt to enlarge in optical continuity the crystal about which they have developed.[2] A dyke running E.N.E. in the wood upon the northern slope of Stanner contains, in addition to a multitude of orthoclase and plagioclase microlites, numerous corroded grains of quartz; each of the latter has served as a centre of devitrification (Fig. 2), and in several instances the highly-interesting observation of MM. Fouqué and Lévy may be repeated on these British spherulites. When comparison is made with similar rocks of much more recent date, it appears at least probable that the mesh-work structure (of quartz and felspar?) is in reality of secondary origin. So far as I am aware, it does not occur, at any rate freely, among the compactly-spherulitic rhyolites of later Tertiary days; but in a dyke traversing the Lias of Broadford, Isle of Skye, and belonging to the pre-Miocene series of eruptions, we have what looks remarkably like the commencement of such a structure by alteration. The spherulites mostly exhibit a dark cross, with, however, a tendency towards a granular condition; and the meshy micropegmatitic appearance occurs only in a few individuals, in a manner strongly suggesting a development of quartz among their previously homogeneous fibres.[3] It is quite conceivable that such secondary quartz might adopt the orientation of an included and rounded crystal, just as it is known to do when deposited in sandstones from solution.

[1] Minéralogie micrographiqne, pl. xii. fig. i.
[2] *Ibid*, pp. 193–94.
[3] Cf. Judd, Quart. Journ. Geol. Soc. vol. xlii. p. 72.

In order to see whether the felsites of Stanner could be correlated with the clearly acid and more crystalline pegmatite, as common offshoots of some granite mass below, I made the following analysis of a specimen from the central area. The specific gravity, determined from a large specimen by Attwood's balance, is 2·62.

Spherulitic Quartz-Felsite, Stanner Rock.

SiO_2 ...	...	74·80
Al_2O_3...	...	13·89
Fe_2O_3...	...	trace
CaO ...	...	2·59
MgO ...	...	·05
K_2O ...	...	2·74
Na_2O...	...	5·45
Loss on Ignition		·77
		100·29

The rock belongs, then, fairly to the Acid series, but to the "granitite" rather than the granite group; similar proportions of the alkalies, implying a fair amount of oligoclase-material, are found even among the rhyolites.

I have not been fortunate enough to find these white felspathic rocks repeated on Hanter Hill, though the community of other characters in the two hills leads one to suspect that they occur.

II. The "Diabase" Series.

The greenstones that compose the bulk of Stanner Rock form various links in the series between the augite-plagioclase rocks and the ordinary hornblende-diorite group. In coarse-grained specimens from Hanter Hill, as well as from Stanner, green fibrous crystalline areas occur that by their extinctions may well be altered enstatite. The pale green products that abound, however, are very largely chloritic, and may be considered "tertiary" in origin, when, as is so frequently the case, they are derived from the acicular or the more massive hornblende that is itself developed at the expense of diallage or augite. Olivine was very probably a constituent part of the summit masses of Hanter Hill; and, following the nomenclature adopted by Prof. Judd,[1] the rock is there a diallage-gabbro traversed by veins of dolerite, to which the small rounded augites give a marked granulitic structure. The felspars are extensively "schillerized,"[2] and even the minuter augites of the dolerites are in the diallage condition, chloritic pseudomorphs resulting from their complete and final alteration. In one gabbro the passage from diallage into hornblende is very beautifully seen.

But many of the greenstones of Stanner show no signs of former olivine, while chlorite is extensively developed in them from diallage, augite, and green hornblende. In one fine-grained holocrystalline rock, with a specific gravity of 2·86, biotite and augite are closely intergrown (Fig. 3), and form, with plagioclase felspar, the chief original constituents. Titanoferrite and prisms of apatite are also present. The biotite and the augite alike pass into green products,

[1] "Tertiary Gabbros, etc., of Scotland," Q. Journ. Geol. Soc. vol. xlii. p. 62.
[2] Judd, Q. J. G. S. vol. xli. p. 383.

among which hornblende is occasionally recognizable; and quartz often fills the interspaces between the sharply-defined ends of felspar prisms. In other specimens, notably in a coarse variety on the most northern summit, ophitic structure prevails, the felspar being labradorite, according to a determination by Szabó's method made by Mr. J. F. Brooks. The most finely-grained rock of this series appears as a compact grey-green vein above Stanner cliff, and, with its porphyritic plagioclase felspars characteristically corroded by the matrix, and its brown clouded patches of augite, at first difficult of recognition, must be classed as an augite-andesite, and, when fresh, must have resembled many Tertiary lava-flows. The whole of the foregoing altered series, from the decomposed (olivine) gabbros to this hemicrystalline vein, come, then, conveniently under the head of "Diabase." It is, however, this very comprehensiveness, sanctioned by long usage—witness "Diabasmandelstein"—that makes the name valueless when limited to one rock-species.

Prof. Judd [1] has recently pronounced against "Diabase" in favour of "Gabbro" for coarsely-crystalline rocks that can be shown to have contained olivine as well as plagioclase and augite, and has discussed the current terminology from a basic point of view. Since there is a growing tendency to employ "Diabase" for the granitic augite-plagioclase rocks, thereby defining closely what has become a really valuable field-term, I may perhaps venture to give briefly a historic outline of the position.

In 1813 Alexandre Brongniart [2] put forward the name *Diabase* for rocks "composée essentiellement d'amphibole hornblende et de felspath compacte," including in this the famous orbicular rock of Corsica. Haüy [3] subsequently employed *Diorite* (implying the distinctness of the two constituents) for the same rocks, which he distinguished from syenite by a greater predominance of hornblende; and this name prevailed so far that Brongniart in 1827 [4] very gracefully yielded up his prior term—invented, as he pathetically remarks, by one familiar with ancient and modern languages—lest science should be cumbered with two names for precisely the same thing. He admits diallage and mica among the accessory minerals of the *Diorite* which he thus helped to establish.

Diabase therefore ceased to exist, until Hausmann [5] very effectually revived it for the series of rocks containing "hypersthene," labradorite, *and chlorite*, varying in structure from highly-crystalline to scoriaceous, which he found associated with his two classes of Diallage-Labradorite and "Hypersthene"-Labradorite rocks. But this "hypersthene" being for the most part only a lustrous augite, analyses revealing its chemical identity with diallage,[6] Diabase

[1] Quart. Journ. Geol. Soc. vol. xlii. pp. 61-2.
[2] "Essai d'une classification des roches," Journ. des Mines, July, 1813.
[3] Traité de Min. 2nde édit. tome iv. p. 536.
[4] Classification des roches homogènes et hétérogènes, p. 80.
[5] Ueber die Bildung des Harzgebirges, 1842.
[6] See vom Rath, "Chemische Untersuchungen einiger Grünsteine aus Schlesien," Poggend. Annalen, xcv. (1855) p. 545.

naturally came to cover all augite-labradorite-chlorite rocks, of whatever grain, *i.e.* (pre-tertiary) altered masses verging on one side into the diorite, and on the other into the (olivine) gabbro series.

What, then, are we to do with the highly-crystalline representatives of the augite-andesites? It seems unnecessary to extend *Eucrite* (augite-anorthite rock), if we can employ some more familiar term. The bulk of the gabbros are, as Prof. Judd has shown, so connected with the basalts, that we are still left with a gap, and into this diabase has somewhat naturally stepped. Messrs. Hague and Iddings[1] employ it in this sense, connecting, in their admirable series of observations, diorite and hornblende-andesite, diabase and augite-andesite; and De Lapparent[2] also makes of his diabases a series exactly parallel to his (hornblende) diorites. But the difficulty of thus defining their position as distinct from diorite is shown by Boricky's[3] use of diabase for hornblende-plagioclase rocks where the former mineral can be shown to have been derived from augite; and the fact that many diorites are in this sense altered diabases must lead to considerable confusion,[4] two parts of the same mass retaining the same essential structure, and yet receiving different names.

Now Zirkel[5] has long ago given us a class of *augite-diorites* distinguished from his diabase by containing oligoclase and not labradorite; but now that the nature of the felspar no longer restricts the diorites, this class becomes correspondingly extended and fills admirably the vacant place. Augite and enstatite diorites should seem no more strange than the corresponding varieties of andesite, and the close relations of the pyroxenes and the amphiboles appear to support this comprehensive view, viz. that the diorites form a natural group, containing now hornblende, now mica, now augite, or now, as in the case of rocks at Stanner, two or even three of these constituents.

Diabase then remains much where Hausmann placed it, as a common term for the more basic altered augitic rocks, without question as to their age or much regard for structure. Not that it is better in itself than "Greenstone," but that it is sanctioned by more international usage. My excuse for dwelling thus far on what may seem foreign to the mere description of the rocks of Stanner lies in the fact that so many areas of augite-plagioclase rocks (Augite-Diorites) occur upon our western border. Vague and general terms are too valuable to be lost sight of in the field; but the use of an inexact name where another more closely expresses an observed relationship can only be, and has been in the past, a source of misapprehension and confusion.

Many of the rock-sections above referred to have been made, and the chemical work has been carried out, in the Geological Laboratory of the Normal School of Science and Royal School of Mines.

[1] Bulletin U. S. Geol. Survey, No. 17.
[2] Traité de Géol. 2me édit. p. 627.
[3] Tscherm. Mittheil. ii. (1880) p. 78.
[4] See Hague and Iddings, Bull. U. S. Geol. Surv. No. 17, p. 21.
[5] Lehrbuch der Petrogr. (1866) ii. p. 7.

NOTICES OF MEMOIRS.

I.—Report on a Series of Specimens of the Deposits of the Nile Delta, obtained by the Recent Boring Operations. By J. W. Judd, F.R.S., Pres. Geol. Soc. Proceedings of the Royal Society, No. 240, 1886, pp. 213–27.

THIS paper contains the results of a microscopic analysis of specimens from the borings, which have lately been carried on, under the auspices of the Royal Society, in three different places in the Nile Delta. That at Kasr-el-Nil, Cairo, was carried to a depth of 45 feet, whilst those at Kafr-ez-Zayat and Tantah, places about half-way between Cairo and the Mediterranean, were 73 and 84 feet deep respectively. In none of these borings was the rocky floor of the Nile valley reached. The beds passed through consisted of an admixture, in varying proportions, of blown sand and alluvial mud. The *sands*, when examined under the microscope, are seen to consist of two kinds of grains; the larger, usually perfectly rounded and polished, are of quartzitic materials evidently derived from granitic rocks, with particles of red and brown jasper, Lydian stone, fragments of silicified wood, nearly unaltered felspar grains, hornblende and jade. The smaller sand grains, often subangular and angular, include a greater variety of minerals than the larger, and comprise, in addition to those above mentioned, mica, augite, enstatite (?), tourmaline, sphene, iolite (cordierite), zircon, fluorspar, and magnetite, all in a nearly unaltered condition. These sand grains have been derived either directly from the breaking up of granitic and metamorphic rocks, or from older sandstones formed of the *débris* of these rocks.

The *mud* is singularly deficient in kaolin, and seems to be composed of extremely minute chips and flakes of quartz, felspar, mica, hornblende and other minerals, mingled with some organic particles and frustules of Diatomaceæ. In the Tantah boring fragments of tufaceous limestone were also met with.

The striking feature in the character of these delta deposits is the comparatively unaltered condition of the felspars and other complex silicates in the sands and muds, and the absence of kaolin. Under the usual processes of disintegration of rocks in temperate climates, the felspars and other silicates are reduced by chemical action to soluble silicates of potash, soda, etc., and carried away in solution, whilst the kaolin remains behind. It appears, however, from the nature of these deposits, and from the small amount of soluble solid matter in the water of the Nile, notwithstanding the concentration resulting from extensive evaporation, that chemical action has had but little effect in the drainage area of the Nile, in comparison with the mechanical influences resulting from extreme variations of temperature, the action of the winds, and torrential rains. G. J. H.

II.—Ueber die Fossilen Säugethier-Ueberreste von Baltavár. Von J. Pethö. Jahresbericht d. K. Ung. Geolog. Anstalt für 1884, pp. 63–73. Budapest, 1885.

On the Fossil Mammalian Remains from Baltavár. By Dr. J. Pethö. Annual Report of the Royal Hungarian Geological Survey for 1884.

ABOUT 35 years since, some remains of fossil mammalia were discovered near Baltavár, in the Trans-Danubian province of Hungary, which Prof. Suess determined to be nearly entirely identical with the Pikermi fauna. They consisted of the following species: *Machairodus cultridens*, *Hyæna hipparionum* (=*H. eximia*, Gaudry), *Dinotherium*, *Rhinoceros*, *Sus erymanthius*, *Antilope brevicornis*, *Helladotherium Duvernoyi*, and *Hippotherium gracile*. The deposit was supposed to have been exhausted, but now lately fresh remains have been discovered by the Hungarian Survey, and from these, and from the collection stored in an adjoining monastery, Dr. Pethö has determined the under-mentioned list of fresh species, which further show a remarkable connection with those from Pikermi. They include *Mesopithecus Pentelici*, Wagn., *Dinotherium giganteum*, Kaup, *Mastodon Pentelici*, Gaudr. et Lartet, *Tragoceros amaltheus*, Roth-Wagn., *Cervus*, sp., cf. *Matheronis*, Gerv., *Chalicotherium Baltavárensis*, n.sp., and *Rhinoceros pachygnathus*, Wagn.

REVIEWS.

The Survey of Western Palestine. Memoir on the Physical Geology and Geography of Arabia Petræa, Palestine, and Adjoining Districts, With Special Reference to the Mode of Formation of the Jordan-Arabah Depression and the Dead Sea. By Edward Hull, LL.D., F.R.S., 4to. pp. 145, with Maps and Sections. (Published for the Committee of the Palestine Exploration Fund, 1886.)

IT is now generally recognized that the social and political history of the inhabitants of any country has been largely influenced by its physical characteristics, and that consequently in order to elucidate the one, it is necessary to obtain a thorough knowledge of the other. The Committee of the Palestine Exploration Fund, in its efforts to obtain a complete knowledge of the ancient inhabitants of Palestine, took therefore a wise step in organizing an expedition to this country to study its physical structure. Prof. Hull was chosen as the leader of the expedition, and the present memoir gives the outcome of his observations.

The geological features of Palestine and the adjoining regions have for many years past been pretty well known through the works of several competent investigators, amongst whom may be mentioned Bauerman, Lartet, Milne, Fraas, Ritter, Russegger, and others, and considerable light has also been thrown on its geology by the explorations of Zittel in the Libyan Desert. A very excellent résumé of the existing knowledge of the subject has been given by

Mr. W. H. Hudleston, in a presidential address to the Geologists' Association in 1882, to which the same author added further notes in March, 1885.

It can hardly be expected that in the course of the short period of two months, in which the active work of the Expedition was carried out, Prof. Hull should have been able to add very materially from his own observations to the already existing knowledge of the subject. But though the contents of this memoir have been, to no small extent, derived from secondary sources of information, it is still a valuable contribution to the geology of Palestine, and the statements and opinions it contains will be, by many, more relied on than those of equally competent but supposed less orthodox investigators. As a rule, however, Prof. Hull's researches confirm those of previous investigators. By a strange irony of fate indeed, the author has proved that one of his own pet theories of the former outflow of the Jordan, through the Arabah valley into the Red Sea, is not tenable, and he now finds the water-parting in this valley to be some hundreds of feet above the level which the waters of the Dead Sea basin reached, even in their greatest extension.

As regards the ancient crystalline rocks of the Sinaitic region, the author accepts, though somewhat hesitatingly, the views of Fraas and others that they are of Archæan or Laurentian age. On this supposition, the volcanic series which penetrates through them may be, the author states, "of Lower Silurian age, but if we consider the older schists to be metamorphosed Cambro-Silurian beds, then the newer series may be of Upper Silurian or of Devonian age." It would be interesting to know the grounds, if there are any, for considering these crystalline schists to be of Cambro-Silurian age. The author says in a footnote, "As in the case of those portions of the British Isles where the Lower Silurian rocks have been metamorphosed previous to the deposition of the Upper Silurian beds to which they are unconformable." We fail to derive any assistance from this remarkably indefinite comparison, and should have preferred to have had a more particular reference.

There is a great gap between the Archæan crystalline and volcanic rocks of the Sinaitic peninsula and the succeeding formation of purple and red sandstones, of Carboniferous age, which overlie them unconformably. In the Wady Nasb this sandstone is covered by a band of limestone, in which Mr. Bauerman discovered fragmentary fossils of Carboniferous age. Some doubt was thrown upon the determination of these fossils, but this expedition obtained others which decisively prove the Lower Carboniferous age of the limestone, and the sandstones beneath are also regarded as of the same period. The band of Carboniferous limestone is, in its turn, overlaid by sandstones of similar characters to those beds below it, and these higher or Nubian sandstones pass upwards into limestones of Cretaceous age, and are themselves probably of Cenomanian age. In the absence of the Carboniferous limestone band—which appears to be not extensively developed—there are no means of determining whether the basal beds of the variegated sandstones are Carboniferous

or whether they are wholly Cretaceous and belong to the Nubian series. At the Wady Nasb the Carboniferous sandstone is from 150 to 250 feet in thickness, and Prof. Hull assigned to it the not very distinctive name of "the Desert Sandstone," whilst for the Cretaceous sandstone, which has an extremely wide development both in Palestine, the Sinaitic Peninsula, Egypt, and the Libyan Desert, the name of the "Nubian" Sandstone is retained.

Another outcrop of the Carboniferous Limestone is believed to have been met with by the Expedition among the hills of Moab, east of the Ghor, but "for lack of time" the fossils in it were not collected, and Prof. Hull does not therefore feel confidence respecting its age.

No fresh details of importance were noted respecting the Cretaceo-Nummulitic series of rocks of which the greater part of Palestine and of the country east of the Jordan valley is composed. The series consists of the Nubian Sandstone below, followed by thick beds of limestones with bands of chert. The succession and the character of the rocks very much resembles that described by Zittel in the Libyan Desert, and there is also a similar absence of any clear line of demarcation between the limestones of Cretaceous and those of Eocene age. Fossils appear to be rare throughout the series—the Expedition does not seem to have discovered any in fact. It would be interesting to know whether the numerous bands and masses of flint and chert, which occur equally in the Cretaceous and in the Eocene strata, are, like those of the Upper Chalk of England, derived from siliceous sponges; but nothing is noted about them beyond that shells of Molluscs and Echinoderms now siliceous are occasionally found in them.

The author briefly refers to the occurrence of beds of a calcareous sandstone, the presence of which is stated to be the key to the physical features of the western margin of Palestine from Mount Carmel to beyond Gaza. No thickness is assigned to the deposit, its conformability or otherwise to the Eocene limestones below is not mentioned, and the only fossils in it are unrecognizable fragments of shells.

The author refers the formation provisionally to the Upper Eocene, "chiefly on the grounds: (1) that it is older than the sand and gravel of the 200 feet sea-border, which may be inferred to date back to the Pliocene: (2) that there is no evidence of any Miocene beds in Palestine; and (3) that the rock has a very solid character and is traversed by joint planes, similar to those of the Cretaceo-Nummulitic limestone." The rock may indeed belong to the Upper Eocene, but the grounds on which it is so placed are of the weakest character. Thus, because Miocene beds are not known elsewhere in Palestine, is certainly no argument why these beds may not belong to this period, and as for the very solid character of the rock being evidence of its Upper Eocene age, it is stated on the preceding page that this rock "*is sometimes rather solid, but generally porous.*"

With the great uncertainty respecting the age of this calcareous sandstone, it would seem to be rather premature on the part of the author to devote a chapter to the subject of "Miocene period unrepresented in Palestine and Border," in which it is stated that in

Palestine and Idumar this period is "one of disturbance and elevation, of faulting and flexuring and denudation of strata."

In the chapter on "Later Pliocene to Recent Beds (Pluvial)," the author points out that after the leading features of the land and coast-lines had been formed by denudation, there was a depression of about 220 feet in relation to the present sea-level. The evidence for this is the presence of raised beaches with recent shells in the vicinity of Cairo, also near Gaza and Jaffa at elevations of about 220 feet. The author also discovered recent corals and shells in gravelly beaches in the Arabah valley at elevations of 80 and 130 feet above the sea-level.

A depression of about 220 feet would unite the basins of the Red Sea with the Mediterranean, and at the shallowest part of the channel between them there would be a depth of 150 to 170 feet of water. On the theory of the union it is difficult to explain the remarkable differentiation which exists between the faunas of the Mediterranean and the Red Sea at the present day, for if there was such an open channel in Pliocene times, the period which has since elapsed does not seem sufficiently long to have given rise to the extreme dissimilarity which now exists. Prof. Hull assumes that the two seas were disconnected in Miocene times and that the differentiation which took place in that interval was not materially interfered with by the Pliocene communication; since the water was not deep enough to allow of free commingling of the two faunas. To most naturalists this will appear an unsatisfactory and untenable explanation.

The author refers in some detail to the terraces of marl silt and gravel with fresh-water shells in the more elevated beds, which mark the different elevations of the water in the Jordan-Arabah valley up to a level of about 1400 feet above the present surface of the Dead Sea, or about 100 feet above the Mediterranean.

The Jordan-Arabah depression is ascribed to the direct result of a fault or fissure of the crust, accompanied by a displacement of the strata, arising from the tangential pressure of the Earth's crust due to contraction, and the depression was produced at the close of the Eocene period. It is thought probable that the first waters of the Dead Sea basin were those remaining from the ocean itself, and that the fauna of the Lake of Tiberias may thus have had, in the main, a marine origin. The author does not venture to apply this theory to the distinctive species of *Unio* and other fresh-water mollusca, now inhabiting the Jordan Valley, but regards the fishes as the descendants of those which lived in the waters of the Eocene seas. It is, of course, possible, but we should like to have seen some facts brought forward in favour of the hypothesis.

According to the author this isolated basin-full of Eocene salt-water then suffered a process of contraction, whether from evaporation or otherwise, is not stated, and at the close of the Miocene, or at the commencement of the Pliocene, the waters had been reduced to about the level they are at present, and in the meantime the region was being carved out by denudation into the hills and valleys of the present day. This contraction is correlated with a similar reduction

in volume of the Mediterranean Sea—whether both originate from a common cause is not stated; but whilst the reduction of the Mediterranean is inferred to have taken place "at an epoch not very remote and which may be represented by the Interglacial stage of the Quaternary period," the reduction of the Dead Sea is placed further back, at the beginning of the Pliocene.

The next stage in the geological history of the Dead Sea to which the author introduces us is that of "The Pluvial Period (Pliocene and Post-Pliocene)," in which there was a general subsidence of the whole region bordering the Levant and a general rising of the inland waters, till the Jordan-Arabah depression was filled by a lake (fresh-water?) over 200 miles in length and over 2000 feet in depth. This great change appears to have been produced by the climate of the Glacial period, when the temperature of Palestine is stated to have been 25° Fah. lower than at present, and the climate resembled that of the British Isles. But the Dead Sea basin even then was not filled to the brim, and it would at that time have required no small engineering capacity to have cut a canal through the water parting in the Arabah valley, to unite its waters with those of the Red Sea.

Subsequently to the Pluvial period we are told by the author that the more modern physical conditions set in, and by gradual degrees the waters in the Dead Sea basin were for a second time reduced to the low level now existing.

The author devotes a special chapter to the "Origin of the Saltness of the Dead Sea," from which it appears to be his opinion that it is merely owing to the concentration by evaporation of the saline ingredients which the rain-water of rivers and streams has dissolved out of the strata through which it passes.

The author makes the following novel comparison between the water of salt lakes and that of the ocean: "It is probable that the water of the ocean itself has become salt owing to the same cause which has produced saltness in the inland lakes, as it may be regarded as a mass of water without an outlet." It is, however, arguing in a circle to attribute the saltness of the ocean to the land, whilst the land itself, including the salt (leaving eruptive rocks out of the question), may be attributed to the ocean.

The author makes no allusion to what has become of the enormous mass of solid materials which has been removed from the surface of the drainage area of the Dead Sea, and carried into its basin. Some of it is, of course, represented by the terrace deposits, but we can hardly account for the rest, without supposing that the depression of the Dead Sea has originally been much deeper than it is now, and that it has been partially infilled.

In an appendix Mr. F. W. Rudler describes the microscopic structure of the specimens of crystalline rocks collected by Prof. Hull in Arabia Petræa.

The work is illustrated by two geological maps and by numerous sections and profiles which show very distinctly the stratigraphical relations both of Palestine itself and the Sinaitic peninsula.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—March 24, 1886.—Prof. J. W. Judd, F.R.S., President, in the Chair. The following communications were read:—

1. "On the Genus *Diphyphyllum*, Lonsdale." By James Thomson, Esq., F.G.S.

The author commenced by giving a definition of the genus *Diphyphyllum*, and then proceeded to discuss its relations with some allied forms, such as *Lithostrotion*, *Lithodendron*, and *Campophyllum*. *Diphyphyllum* was shown to be restricted in Scotland to the lower portion of the Carboniferous system, and not to have survived the great development of volcanic action in the upper part of the Carboniferous-Limestone series, whereas in Belgium and elsewhere the range of this genus was more extensive.

It was shown that in *Diphyphyllum* reproduction took place both by fissiparity and by calicular gemmation, examples of both forms being cited. It was also pointed out that the development of central vertical plates, showing a tendency to a passage into *Lithostrotion*, was due to the corals having lived in a sea periodically affected by the influx of sediment from the neighbouring shore.

After a history of the views held by different writers since Lonsdale, and especially by M'Coy, Milne Edwards and Haime, Hall, Billings and De Koninck, on corals referred to this generic type, the author gave a description of the species found in North Britain, ten in number, of which seven were new; and after pointing out their differences, showed that all exhibit a tendency to vary, and that, if a sufficient series were available, a passage might be traced not only between these different species, but between *Diphyphyllum* and the various allied genera.

2. "On additional Evidence of the Occurrence of Glacial Conditions in the Palæozoic Era, and on the Geological Age of the Beds containing Plants of Mesozoic Type in India and Australia." By Dr. W. T. Blanford, F.R.S., Sec. G.S.

After recapitulating briefly the principal facts known as to the correlation of the Karoo formation of South Africa, the Gondwâna system of India, and the Coal-measures and associated beds of Eastern Australia, and especially noticing those phenomena in the different strata that had been attributed to the action of ice, the author proceeded to describe the additions recently made to previous knowledge by various members, past or present, of the Geological Survey of India, and especially by Mr. R. Oldham and Dr. Waagen. These additions had recently been published in the Records of the Geological Survey of India.

Mr. R. Oldham, in a recent visit to Australia, had come to the same conclusion as all other geologists who had visited the country, and clearly showed, as the Rev. W. B. Clarke and many others had done, that beds containing *Glossopteris*, *Phyllotheca*, and *Nœggerathiopsis* were intercalated among marine beds with Carboniferous

fossils. The age of these marine beds was shown by Dr. Waagen to be that of the European Coal-measures. Mr. Oldham, had however, further ascertained the presence in abundance of smoothed and striated boulders, evidently transported by ice, in the marine Carboniferous beds north of Newcastle, N.S.W., and he consequently considered these beds, and not the overlying Hawkesbury, the equivalents of the Bacchus-marsh beds of Victoria, and of the Talchirs of India, a view which was in accordance with the relations of the fossil flora.

Meantime Dr. Waagen had received from Dr. H. Warth some fossils from the Salt-range of the Punjab. The fossils came from the upper part of a boulder-bed, the resemblance of which to the Talchir group at the base of the Gondwána system had long been recognized, but which had hitherto been classed with a stage immediately overlying, containing Upper Cretaceous fossils. The fossils now found by Dr. Warth included two forms of *Conularia* found in the Australian Carboniferous rocks, besides some other species evidently of Carboniferous age. Dr. Waagen consequently classed the boulder-bed together with other similar formations in other parts of the Salt-range as Carboniferous. There was one difficulty, the fossils just referred to were considered by Mr. Wynne to be contained in pebbles derivative from another bed. It was, however, shown that this did not affect the age of other boulder-beds in the Salt-range, and that the latter were connected with the Talchir beds in Central India by another discovery of Mr. R. Oldham's that a boulder-bed in the Indian deserts was also probably of Talchir age, and that the question as to whether the nodules containing the *Conulariæ*, etc., were concretions or pebbles, might await further examination in the field.

Another contribution to the question had been made by Mr. Griesbach, who had recently found a boulder-bed which, from its character and fossils, he considered as Talchir, in the neighbourhood of Herat.

It was pointed out that the existence, over such extensive areas, of boulder-beds, all of which might, without any improbability, be of approximately the same age, rendered it highly probable that all were really contemporaneous and due to one Glacial period; that this period must have been towards the close of the Palæozoic era, which it may possibly have terminated by exterminating many of the principal forms of life. The peculiar flora of the Australian Newcastle beds and of the Indian Damudas, having nothing in common with the contemporaneous European Carboniferous flora, afforded an important proof of distinct botanical provinces in past times.

II.—April 7, 1886.—Prof. J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:

1. "On Glacial Shell-beds in British Columbia." By G. W. Lamplugh, Esq. Communicated by Clement Reid, Esq., F.G.S.

This paper was divided into two parts, relating respectively to Vancouver Island and the Fraser Valley. Having to spend nearly a

month at the city of Victoria in 1884, the author had leisure for the investigation of the geological features of the district, but he expressed his regret that, at the time, he was unacquainted with the publications of Mr. Bauerman and Dr. Dawson on the subject.

The most important shell-beds were disclosed in an excavation for a dry dock at Esquimault, V.I. Here a fissure in an igneous rock had been filled in by glacial beds. Shells were most numerous on the north side of the dock in Boulder-clay, associated with irregular sandy seams, the whole being softer than the general mass. The containing rock was not glaciated at this point. *Leda*, *Nucula*, *Cardium*, *Tellina*, *Mya*, and *Saxicava* are the principal genera.

There was great difference in the state of preservation according to position; the shells below the water-line being remarkably fresh, while acidulous waters, engendered by vegetable decay, had attacked the upper portions.

The author concludes that the whole mass of drift, including the shells, had been pushed up by ice in its passage southwards. The general mode of occurrence was very similar to that at Bridlington. He further observed that the rocks were not striated in the first instance by these shelly clays, but he believed the glaciation to have taken place through the action of harder substances, and that afterwards a milder term set in, when an arctic fauna established itself in the neighbourhood, after which fresh ice pushed the sea-bottom along with other accumulations into its present position.

The shell-beds in the Fraser Valley are about 100 feet above sea-level. Three sections of glacial beds were given. The stratified clay in which the shells were found contains no pebbles, and, though somewhat disturbed, has evidently been deposited where it now occurs.

2. "On a Lower Jaw of *Machærodus* from the 'Forest-Bed,' Kessingland." By James Backhouse, Esq., F.G.S.

The author believed that hitherto no example of a lower jaw of *Machærodus* has been met with in this country; he consequently gave a detailed description and measurements of a right mandibular ramus obtained by him from the Forest-bed at Kessingland, in Suffolk. Owing to the imperfect condition of the incisors and canines, it was impossible to say whether these teeth were serrulated or not, and consequently it was uncertain whether the bone belonged to *Machærodus cultridens* or *M. latidens*.

3. "A Contribution to the History of the Cetacea of the Norfolk 'Forest-Bed.'" By E. Tulley Newton, Esq., F.G.S.

This paper was principally devoted to the description of two fossil specimens. The first of these was a tooth, shown by external and microscopical characters to have belonged in all probability to the Sperm-whale, *Physeter macrocephalus*. The specimen was obtained by Mr. Clement Reid, at Sidestrand. The second fossil, also from Sidestrand, and now in the possession of Mr. James Backhouse, consisted of the right half of the seven anchylosed cervical vertebræ of a species of *Balæna*. The specific determination was less certain in this case; but the form approached most nearly to that of *B. biscay-*

ensis. Of other vertebræ from the Forest-bed, one, a caudal, was referred to *Balæna;* another, from the lumbar region, to *Balænoptera*.

The following specimens were exhibited:—

A series of Plant-remains from the Cromer Forest-bed, exhibited by Clement Reid, Esq., F.G.S.

Specimens from the Shell-beds in British Columbia, exhibited by G. W. Lamplugh, Esq., in illustration of his paper.

Specimens from the "Forest-bed," exhibited by James Backhouse, Esq., and E. Tulley Newton, Esq., in illustration of their papers.

CORRESPONDENCE.

ON THE DISTRIBUTION OF *HIPPOPOTAMUS AMPHIBIUS*.

Sir,—I have lately read with great pleasure Dr. Henry Woodward's interesting and instructive article, on "Recent and Fossil Hippopotami," published in Dec. III. Vol. III. 1886, pp. 114–118, of this Magazine. In that paper, Dr. Woodward assigns to the two species of Hippopotamuses the tropical or warmer parts of Africa as their present habitats. As a generalization of their present distribution, this statement may be accepted as strictly correct, but during my journeyings in South Africa, in the upland regions of Natal, the Orange Free State, and elsewhere, I was surprised to find some of the reedy "*vleys*" or lakes called "*Leekoe Vley*." Such a name is in itself evidence that the Boer immigrants, or early settlers, found Hippopotamuses in such localities; indeed, I have been informed by old settlers that such had been the case in their own knowledge, or else that the natives had told them of the former existence of the animals in such places. I have been credibly informed that 50 years ago Hippopotamuses were abundant in the Umzinduzi river, close to where now the city of Pietermaritzburg in Natal is built. The fact of these animals having inhabited localities in the uplands of Natal, and the Free State, is I think beyond question, and as those districts are at times subjected to very inclement weather, it raises the question whether the *Hippopotamus amphibius* is not capable of enduring far greater changes of temperature than is usually supposed. I was encamped in the vicinity of Newcastle, Natal, on the borders of the Transvaal, in the winter of 1881 (*i.e.* the summer of our northern hemisphere), and we experienced very severe weather. Water froze in the buckets left outside the tents at night, the snow lay deep over the country, herds of sheep and cattle were buried and frozen to death in the snow. Many farmers suffered great loss in stock. In the highlands of the Orange Free State, across the Natal border, the losses of flocks and herds from the snowstorms were greater than in Natal. The question arises, whether Hippopotamuses were denizens of these upland lakes and rivers, or only summer visitors. If residents, they must have been subjected at times to extraordinary changes of climate. I regret that during my residence in South Africa, I did not pay more attention to this interesting subject.

I venture to send you this communication in the hope that it may attract the attention of some naturalist in South Africa, of greater experience than myself, as the subject is one of considerable interest to the geologist.—I am, Sir, your obedient servant,

WELLS, NORFOLK, *2nd April*, 1886. H. W. FEILDEN.

DISCOVERIES IN THE PUNJAB SALT-RANGE.

SIR,—Since the abstract of my paper to the Royal Geol. Soc. of Ireland on the subject of Dr. Warth's discoveries in the Eastern Salt-range appeared in the GEOLOGICAL MAGAZINE for March, a paper on the same subject by Dr. Waagen, of Prague, in the Records of the Geol. Survey of India (vol. xix. pt. 1), has reached me. Several points in this paper relate to the stratigraphy of the Salt-range as interpreted in my Geological Survey Report, and one or two especially touch portions of my paper referred to, and its abstract.

With reference to these last, I may notice that certain of the fossils to which I alluded as undetermined have now been fully described by Dr. Waagen, and are referred to the Carboniferous, not Devonian age, as I had been informed. Beyond accepting the purely palæontological determinations of Dr. Waagen, I have little to say: he gives his evidence, describing most of the species as new or indeterminate, or requiring further comparison, and he appears to be *now* satisfied as to their age. Their reference to the later period tends to reduce the interest which the discovery of Devonian forms would have possessed, on account of the absence of recognizable Devonian rocks, in that or the adjacent country.

Dr. Waagen's paper, however, differs from my own in describing these fossils as having been found in concretions, not in pebbles, and as occurring *in situ* in the *Conularia* layer. Upon this point rest very extensive and important deductions, and it is one upon which some uncertainty seems to have prevailed, leading both Dr. Warth and Dr. Waagen to reconsider matters and to change their minds: hence I am glad to learn we may expect to hear further about the matter from the officers of the Geological Survey of India.

Dr. Waagen's latest announcements, as above stated, seem to date from the end of last year or the very commencement of 1886. Dr. Warth, writing to me with specimens from this layer (and some others) under date Dec. 1, 1885, strongly maintains that the fossils are not *in situ*, but derived, and in support of this he calls attention to one of the specimens, a single rolled fossil *Conularia*, which itself formed one of the pebbles of the layer. Turning to the specimens I received (and they were few), I found they consisted of fine, pale, non-calcareous sandstone, presenting no signs of concretionary structure, their smoothed surfaces intersecting the inclosed fossils, while the special example referred to has all the appearance of a once more perfect fossil detached from its matrix, abraded and rolled till its general form alone remains, with just sufficient of its original markings to show certainly what it is. Another of the same kind shows only the outer form, and greater abrasion.

On this confirmatory evidence I adhere to the view expressed in my paper as to the derived or *remanié* character of the *Conularia* layer, until something more conclusive is brought forward than has been yet produced.

The "Olive group" of the Salt-range which contains this *Conularia* layer, from its circumstances of position and from a few of its fossils, found in a determinable state, was classified by Dr. Waagen and myself as probably of Cretaceous age, before he left the Punjab.

It has been recorded for years that certain Boulder-beds, lying just beneath this *Conularia* layer, and included in the Olive group, contain glaciated blocks, and resemble the Talchir Boulder-beds of the Gondwána series in Peninsular India; also that there are in other parts of the Range, and at different vertical positions in its sections, Boulder-beds of very similar aspect.

I have never found reason to believe that the stratigraphic relations of these Salt-range Boulder-beds supports the idea now advanced, that all occur upon one and the same horizon; and I must say I am still unconvinced of the fact, while admitting that this would be both important and interesting if proved.

KINGSTOWN, 19*th March*, 1886. A. B. WYNNE.

THE PALÆONTOGRAPHICAL SOCIETY.

SIR,—The fortieth volume of the Memoirs of the Palæontographical Society is now in progress; with the current year the series will have completed the number generally assigned to a period of probation. That it has well endured the trial of time none can deny. The unremunerated labours of many of the leading palæontologists of Britain have enriched their fellow-workers with a series of monographs, sometimes dealing with various genera or classes, sometimes presenting a synoptic view of certain portions of the fauna or flora of an important Geological period. To these workers and to all who have taken an active part in the direction of the Palæontographical Society, geologists, not of Great Britain only, are deeply indebted. Never, we may confidently assert, has so magnificent a series of admirably illustrated monographs been placed in the hands of students or at so low a price. For an annual subscription of one guinea, a bulky volume is received, containing usually about thirty plates and three hundred pages of letterpress. At the present time monographs are in preparation or in progress on Pleistocene Mammals and Old Red Sandstone Fishes, on Jurassic Ammonites and Gasteropods, on Cretaceous Starfishes, on Palæozoic Sponges and on the Flora, both of the Carboniferous and of the Eocene periods. There is evidently no failure either in material or in writers. Moreover, up to the present time the Society has successfully paid its way and has occasionally had a small balance to the good. Death however of late years has unfortunately removed many of the original subscribers, and new members come in more slowly than might have been expected. Accordingly the Secretary announced at the last meeting of the Council that very shortly, unless there was a substantial increase in the number of subscribers, the quantity of matter

included in the annual volume must be reduced, and thus the issue of the monographs delayed. This announcement is not altogether creditable to the geologists of Great Britain. The number of persons interested in the study of this science has not diminished, nay, has become decidedly larger, since the foundation of the Palæontographical Society. Many more than those whose names are on the list of subscribers could well spare the annual guinea needed to secure the efficiency of the work, but it may be feared that there is among them some lack of public spirit. The rapid development of every branch of geology has perhaps contributed to this by rendering its students more of specialists than they formerly were; but even if the number of monographs in the series bearing on this or that man's hobby be small, he is bound, I think, on public grounds to see that this useful work does not languish for want of funds. In almost every career of life there are certain associations to which one feels bound to belong: may I then be forgiven for suggesting that every geologist not absolutely impecunious should consider the Palæontographical Society one of these. True, the number of back volumes is now formidable to those who desire a complete set, but these can be purchased on easier terms by subscribers, and the less wealthy student may console himself for a broken series by the thought that he is doing a good work in securing its continuance.

T. G. Bonney.

NOTES ON PHENACODUS.

Sir,—I must remark on your late article on *Phenacodus*[1] (Geological Magazine, No. 260), that having selected for publication my earliest conclusions regarding it, issued in 1881, my more mature views are not stated. In order to insure the dissemination of the latter rather than the former, through your journal, I give the following points.

A few months after the publication of the note from which you have principally copied, I published a systematic analysis of the Ungulata in the Proceedings of the American Philosophical Society (1882), in which it was shown that the carpal bones in *Phenacodus* are in linear and not alternating series, and that it therefore cannot be referred to the Perissodactyla. With the Hyracoidea and other forms having similar carpal and tarsal characters it was placed in an order Taxeopoda. This order I regarded and still regard as ancestral to all Ungulata, Amblypoda and Proboscidea included. It thus realized, so far, the prophecy which I made in 1874 (Journal Academy Philad.), that the ancestral type of higher Mammalia would prove to be pentadactyle and bunodont. The history of this question is set forth in my illustrated account of the Condylarthra published in the "American Naturalist" for 1884.

A further study of the extinct Taxeopoda has shown me that although furnished with hoof-like unequal phalanges, they are not very different from the Lemurs of the primitive type known as the Adapidæ. I now believe that the order Taxeopoda must include

[1] See February No. pp. 49–52, Pl. II.

not only *Phenacodus* and allies (=Condylarthra), but also Hyracoidea, Lemuroidea, Simmopithecoidea, and Anthropoidea, although the last-named diverge a little in the characters of the carpus. Moreover, some of the Taxeopoda of the Puerco epoch show that the Unguiculate forms can readily have descended from them, for as the carpus and tarsus of this order are thoroughly Unguiculate, it only requires intermediate forms of ungues to connect them, and these have been found. These facts and conclusions are set forth in the "American Naturalist" for 1885, in a paper on the "Evolution of the Vertebrata Progressive and Retrogressive."

It thus appears that Lemurine forms were the ancestors of all Placental Mammalia, as was already anticipated by Haeckel in his far-seeing "Schöpfungsgeschichte." E. D. Cope.

NOTE ON *ERISICHTHE*.

Sir,—A careful perusal of Mr. Davies' note on this subject in your number for March reveals the fact that he agrees with me in the association of the fin-spines in question with *Erisichthe*, and not with *Ptychodus*. He corrects me as to the authorship of the term *Xiphias Dixoni*, and agrees with me again that the weapon of that species also belongs to the fish I have called *Erisichthe*. But he wishes me to use the name *Protosphyræna*, Leidy, in the place of the one I have proposed. In this point I hope Mr. Davies will yet again agree with me.

Two species are catalogued[1] by Leidy under the name of *Protosphyræna*, *P. ferox* and *P. striata*. If now his *P. ferox* be a species of the genus I have named *Erisichthe*, Leidy's name should, in accordance with all usage, be retained for the *P. striata*, provided the two belong to different genera. When in London, in 1878, either Mr. Davies or Mr. E. T. Newton showed me a jaw containing teeth of the *P. striata*, which was plainly not an *Erisichthe*. For this statement I depend on memory alone. If I be correct, it is for this genus that the name *Protosphyræna* should be retained, if it be used at all.

In its present status, however, the name in question is *nomen nudum*, and under the rules not more entitled to recognition than new names in museum or sale catalogues. The rules of the American and British Associations are explicit on this point, and properly so. E. D. Cope.

NOTOCHELYS COSTATA, OWEN.

Sir,—In his description of this interesting fossil,[2] Sir Richard Owen stated that the "nature and age of the deposit from which it came was unknown to him." I am informed by Prof. Archibald Liversidge, by whom *Notochelys* was sent to Prof. Owen, that it was found associated with certain other fossils described[3] by myself from

[1] The name is not referred to in the text of his paper by Leidy, but only appears in a catalogue at the end of it.

[2] Quart. Journ. Geol. Soc. 1882, vol. xxxviii. p. 178.

[3] Journ. R. Soc. New South Wales for 1883 [1884], vol. xvii. p. 87.